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WATERBORNE TYPHOID:

A HISTORIC SUMMARY OF LOCAL OUTBREAKS IN GREAT BRITAIN AND IRELAND, 1858-1893.

(With a Tabular Analysis of 205 Epidemics.)

A Report prepared for the Parliamentary Bills Committee of the British Medical Association.

ROYAL COLLEGE OF SURGEONS OF
22 OCT 97

BY

ERNEST HART, D.C.L.,

CHAIRMAN OF THE COMMITTEE.

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INTRODUCTION.

It is now some sixteen years since any summary report was made on the relation of typhoid fever to water. In the report which I then made regard was had mainly to nineteen separate outbreaks of the disease which had been ascribed, and indeed traced, to the consumption of specifically polluted water.[1] These outbreaks covered a period of time commencing with 1867, and ending with 1879. The outbreaks of typhoid fever, which were set out in full in a summary table appedded thereto, giving the chief facts which had led to the inculpation of drinking water as their cause, were all of them such as had been investigated by inspectors of the Medical Department of the Local Government Board or its predecessor, the Privy Council Office. This plan suggested itself on account of the fact that the major part of the larger outbreaks had been investigated by the Government Department. In great degree this is true of the numerous outbreaks which have manifested themselves since that report was written. Nevertheless, there have still been many that have had ample investigation at the hands of local health officers and others; and which are deserving of a place in any comprehensive list of waterborne typhoid fever prevalences.

In accordance with a numerously expressed wish that there should be placed on record a historical summary of the waterborne typhoid outbreaks of the last quarter of a century, in so far as the British Isles at least have been concerned, I have attempted this and something more, since I have gone as far back as 1858. My chief reason for going back to that date has been that the reports of the Medical Officer to the Privy Council, and later to the Local Government Board, begin with that year, and have been since continued in unbroken sequence; and, since I foresaw that I should have much recourse to this very numerous and valuable series of annual volumes, it seemed a suitable date from which to begin the compilation of the summary.

I have been the more willing to undertake the present task since I have long felt, that the history of waterborne typhoid deserves to be writ exceeding large. In entering upon this laborious piece of work I have not been without misgiving as to the difficulty of accomplishing it; and so it will be well that I should here say that I by no means lay claim to have made a summary of each and every waterborne typhoid outbreak that has occurred during the thirty-six years 1858-93. Such a feat would be well-nigh impossible of accomplishment, since accounts of many outbreaks never reach beyond the confines of the locality in which the disease manifests itself. But if I must needs concede this much there is at least the satisfaction of knowing that the outbreaks which I have succeeded in summarising are an extremely large percentage of those which have been placed on public record.

Not least difficult to hear of have been some of those which have been the subject of inquiry by the State, since I cannot find that all the reports which have been made as a consequence have been printed or in other ways made public. To this extent, then, my record will be imperfect, as well as in regard to those reports which, having been considered of local moment only, have not been publicly noticed. That there are others, again, that do not find place in my appended summary I am confident; but all that I could do to make the summary as complete as possible has been done. In this work I have had the great advantage of the able assistance and laborious co-operation of Mr. W. H. Huddart. And as a result I have confidence that it will fulfil every purpose for which it is intended so far as completeness of record goes. That it does not profess to be quite complete need not detract from its utility, but should rather lend added significance to the data given as being, if anything, an understatement of fact.

METHOD OF PROCEDURE.

The plan adopted in preparing my summary has been to arrange the notes in tabular fashion, giving in regard of each separate outbreak, so far as obtainable, facts as to (1) date of occurrence, (2) locality, (3) name of reporter, (4) number of cases, (5) number of deaths, (6) population of invaded locality, (7) population using the implicated water,

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[1] Memorandum of Recent Epidemics produced by Polluted Water Supply; Conference on National Water Supply, Sewage and Health at the Society of Arts, May 16th, 1879.

(8) number of cases among consumers of the water, (9) percentage of such cases to the total number, (10) the exciting cause of the outbreak, (11) the circumstances implicating the water, (12) general observations, and (13) a reference to the report dealt with. In this way I think I have covered all the ground necessary to an understanding of each occurrence. And here I would express my indebtedness to those health officers and others who have kindly helped this inquiry in regard of those outbreaks concerning which neither I nor Mr. Huddart had all the facts in our possession. I am, of course, indebted in very large degree to the reports of our Department of Public Health for my facts, next to them to the pages of the British Medical Journal, and also to not a few annual and special reports of local health officers.

Mortality from Typhoid Fever.

Pausing for a moment to consider the broad question of fatality of the disease, I would especially draw attention to the fact that though we can only by the medium of mortality measure the extent of misery caused by this most preventable of diseases, yet the data thus acquired enable us to see something of the enormous amount of physical suffering and disablement, to say nothing of the burden to the rates, which spring from the continued existence of a malady which is a blot on the sanitary escutcheon of our empire. Speaking of preventable sickness in 1873, Mr. (now Sir John) Simon said that the deaths annually registered in this country were (out of some half million) fully 125,000 more numerous "than they would be if existing knowledge of the chief causes of diseases, as affecting masses of population, were reasonably well applied throughout England."

England and Wales.				England and Wales.			
Year.	Total Deaths.	Death rate per mil ion Living.	Average Annual Death-rate per million Living for each Quinquennial Period.	Year.	Total Deaths.	Death rate per million Living.	Average Annual Death-rate per million Living for each Quinquennial Period.
1871	8.461	371	374	1881	5,529	212	216
1872	8,741	377		1882	6,036	229	
1873	8.793	376		1883	6.078	228	
1874	8 861	374		1884	6.380	236	
1875	8,913	371		1885	4,765	175	
1876	7.750	309	277	1886	5,061	184	179
1877	6,879	279		1887	5,155	185	
1878	7.652	306		1888	4.848	172	
1879	5.860	231		1889	5,011	176	
1880	6,710	261		1890	5,146	179	

The preceding table shows for four quinquennial periods, from 1871 to 1890, the total deaths from typhoid fever in England and Wales in each year and the death rate per million living for each year, and also the average annual death-rate per million for each quinquennial period. In 1870 the actual deaths from typhoid were 8,731, in 1880 they had fallen by 2,000, and in 1890 they had fallen other 1,600. The average annual rates per million were in the successive quinquennia 374, 277, 216, and 179. Dr. Thorne Thorne, in his report to the President of the Local Government Board for 1892-93, in dealing with this same matter says: "Since 1869 differentiation has been made in the returns of the Registrar-General between typhus, enteric fever, and 'simple and ill-defined fever,' the latter term being one the use of which has been rapidly diminishing; and if enteric fever be grouped with simple and ill-defined fever, we find that whereas the mean annual death-rate per million living from those two diseases was 567 in the five years 1869-73, it was only 179 in the five years 1888 92. If during this latter quinquennium people had died from these fevers at the rate at which they died in the former five-year period, there would have been during 1888-92 no fewer than 55,808 more deaths from 'fever' than actually occurred. And had the same mortality from enteric and ill-defined fever obtained during 1892 which prevailed in 1869, no fewer than 14,232 persons who at the end of 1892 had escaped death from such fever would have died during that year. In short, if cholera had recurred in England and Wales between 1867 and 1892—a period during which that disease was practically absent from our midst—on the same scale as between 1849 and 1866, we should still be the gainers by several hundreds of thousands of lives. And our gain in this respect is largely due to the incentive given by reason of cholera prospects, and of the knowledge that the disease would have to be met by improved sanitary administration." Thus this disease is showing rapid decline under a system of ever-improving sanitary administration, and we may look forward confidently to a much greater diminution of our fever mortality as the community become educated to a due sense of the vast importance of wholesome surroundings; and when they come to recognise that the truest measure of economy is to expend their rates in the obtaining of that perfect degree of cleanliness without which there can be no absolute exemption from preventable disease, then, and not till then, can England expect to see enteric fever banished from her midst. Where dirt is there will disease be also. In illustration of the notable results accruing from the execution of efficient sanitary works in a district, I will quote only a few examples. In the case of Merthyr Tydfil, comparison between the enteric fever annual death-rate per 10,000 people living during periods after the completion of such works with that obtaining in periods preceding such works has resulted in showing a fall from $21\frac{1}{3}$ to $8\frac{2}{3}$; at Croydon the fall shown was from 15 to $5\frac{1}{2}$; at Ely from $10\frac{2}{3}$ to $4\frac{1}{2}$; at Penrith from 10 to $4\frac{1}{2}$, and this despite the conditions of water supply, concerning which I shall have something to say at a later stage; and at Stratford from $12\frac{1}{2}$ to 4. These will doubtless serve to illustrate my point. To what large extent the lessons to be derived from these instructive data have still to be learned the following pages will bear witness.

Fatality of Typhoid Fever.

The late Dr. Murchison found that 5,988 cases and 1,034 deaths from typhoid fever distributed themselves on the sexes as follows: males, 3,001 cases, 504 deaths, a per-case mortality of 16.79 per cent.; females, 2,987 cases, 530 deaths, or 17 74 per cent., against a per-case mortality of 17.26 per cent. for the whole number. The excess on females was greater during the first fifteen years of life than in the next thirty years as regarded death by typhoid fever. As regards attack, the Registrar-General has given it as his opinion, after study of the facts shown by the admissions to the Metropolitan Asylums Board Hospitals, that more males than females are attacked between the ages of 5 and 20 years. This being so, then since more females than males die during the years in question, the fatality among females must be much greater from the 5th to the 20th year than it is among males.

Seasonal Prevalence.

There is no doubt that the months of autumn are the seasons during which, under normal conditions, typhoid fever manifests itself in an epidemic form. Dr. Murchison says on this point that: "Not only does enteric fever increase in autumn, but it has been found to be unusually prevalent after summers remarkable for their dryness and high temperature, and to be unusually rare in summers and autumns which are cold and wet......Mere dryness of the atmosphere, however, is not conducive to an increase of enteric fever. On the contrary, warm damp weather, when drains are not offensive, is often followed by an outbreak of the disease. An increased rainfall, however, sweeps away those impurities to which the origin and spread of the disease are in drained towns mainly due; but in undrained places it may conduce to an outbreak of the disease by washing those impurities into water used for drinking purposes, as happened at Festiniog in 1863, and in Dundee in 1864."

WATERBORNE DISEASE.

The relation of water and disease is no new discovery. The doctrine of the relation of the use of the one in a polluted state and the manifestation of the other has had universal medical consent in its favour, so Sir John Simon tells us. He says that "during long ages of history, the common instincts of mankind were even surer and stronger than undeveloped science could be in revolting against the use of unwholesome waters. For instance, among the lessons which survive in modern times from the wonderful intellect and vigour of ancient Rome, the frequent far-reaching aqueducts, which record an unbounded care for the provision of proper urban water supplies, are monuments kindred in spirit, and second only in dignity, to the consummate system of jurisprudence of the same singularly organising people." The time is not long since, however, in which much scepticism existed in this country as to the bad effect on health of even considerable amounts of organic impurity; but in the interval the theory previously held by the majority of medical sanitarians has received the added weight of exact experimental research and proof. It no longer remains a mere theory but is now an accepted fact, the remaining difficulty being to make people see that the existence of disease-provoking properties in their neighbourhood in relation to their drinking water are such as need removal, when such removal entails expenditure of money.

TYPHOID FEVER OUTBREAKS OF DOUBTFUL CAUSATION.

Before proceeding to discuss the data in the tabular statement appended, it will be well to say a few words concerning some outbreaks which do not figure there. I have been at pains to exclude from the summary any outbreaks as to which there could be any reasonable doubt that water had been the medium of spreading the disease. Needless to say, this process of exclusion has entailed a vast amount of careful reading, and a consideration of the niceties which have in not a few cases had to be balanced in order to arrive at the right conclusion. I have no doubt in my own mind that I have in this way excluded from my summary instances of waterborne typhoid fever, but in my desire to be judicial I shall not mind if I have thus erred in a few cases. Sufficient for all practical purposes are the numerous outbreaks which find place hereafter. The following are some of the omitted cases in point:

Ecton.—A report by Dr. (the late Sir George) Buchanan in 1872 showed that of ten persons working in a meadow alongside the Ecton brook, almost all became sick with symptoms of fever and diarrhœa caused by drinking the water of the brook which contained sewage from the Northampton sewage farm. The disease was thus carried into the village, where it spread owing to the prevalence of conditions favourable to its dissemination.

Doncaster.—From the autumn of 1872 to the spring of 1873 there was persistence of typhoid. The town derived its public supply of drinking water from a branch of the river Don, which river was polluted, the soil from which the town also drew water, by way of some 200 wells, being grossly polluted. Evidence was forthcoming in the report made by Dr. Thorne Thorne in favour of the spread of fever by polluted water both from the river which received the sewage of towns higher up the stream, and in which typhoid is generally prevalent, especially such towns as Sheffield, and also by water polluted excrementally, and drawn from wells sunk in a thoroughly polluted soil.

Pemberton and Orrell.—In the case of these districts there was grave suspicion that water had much to do with the outbreak of typhoid in the later months of 1880. The local health officer was of opinion that polluted drinking water had led to epidemic extension of the disease. There was distinct evidence of overflow into a well largely implicated from a sewage-polluted brook. There were difficulties in the way of acceptance of the water theory owing to the area covered by the disease; but the question arose whether a rainstorm just prior to the epidemic outburst might not have led to contamination of the wells and springs by washing into the soil and thence into the waters the liquid filth of privies and the leakage of defective sewers. The main difficulty in the way of acceptance of this explanation lay in the wide extent of the water stratum supposed to be infected and the brief space of time after the storm within which the supposed infection of this water stratum must have taken place.

Longton.—The elucidation of the fever outbreak at Longton, as of that just named, fell to the lot of the late Mr. John Spear. In the case of Longton the implicated water from a particular well was supplied either habitually or periodically to parts of no fewer than seven sanitary districts. Analysis proved the water to be polluted by sewage, and the surroundings of the well were not by any means such as to be desired. So complicated were the interlacings of the water services that Mr. Spear was unable to disentangle them for the purposes of determining their exact relation to the fever incidence. But he held that "while the extension of the disease around various foci of infection was probably due to the existence of a barbarous system of excrement disposal, as regards the medium by which these several scattered and apparently independent foci of infection were set up, the water supply was not free from suspicion."

Chester.—Dr. Ballard, in reporting on the continuance of typhoid fever in Chester in the early part of 1890, was unable to state the exact influence which the water supply, drawn from the river Dee, might have had upon the spread of the disease. But he found that part of the city's sewage was discharged in a crude state into the river in such position as necessarily to be washed, at certain seasons, up to and beyond the intake; and it was absolutely certain that whenever typhoid prevailed in the city such sewage would be specifically polluted. The Dee is, moreover, grossly polluted by the discharge of crude sewage from many places above Chester. Dr. Ballard significantly added that, whereas in 1873 Dr. Frankland was unable to find evidence of previous sewage contamination in samples of Chester drinking water, he was able to do so in 1889, no matter where the sample was taken and irrespective of the time of taking it.

Malton.—The town derives its water supply from a well 196 feet distant from the river Derwent and four miles from the junction of the Rye. The well water is subject to discoloration in times of flood, and expert engineers have been of opinion that the river water gains access to the well by way of underground channels. Dr. Bruce Low has set out the full facts in his report of 1893 to the Local Government Board on enteric fever in the valley of the Rye. Concerning the relation of water supply and disease as cause and effect, Dr. Low states that during the last twenty years enteric fever and diarrhœa have persisted in the town, there having been several sharp epidemics, as in 1873, 1878, and 1890. Moreover, the incidence of these diseases was noticed to be greatest immediately after flood times and after the water had been served in a turbid state. Recent diminution in the amount of these maladies is to be thought of as resulting from the action of the engineer in ceasing to pump from the well during times of flood, this fact appearing to strengthen the case against the water as a cause of those diseases. The interchange of water between the sewage-polluted river and the well seemed to admit of no doubt.

Penrith.—Dr. Bruce Low, in reporting to the Local Government Board on the general sanitary condition of Penrith in 1893, made reference to reports by Dr. Robertson, the local health officer, and by Mr. T. W. Thompson—Dr. Low's colleague of the Medical Department at Whitehall—concerning an outbreak of typhoid fever in 1891 affecting the town of Penrith and a portion of the adjoining rural district of the same name. All the cases occurring up to August of that year—some 40, with 4 deaths—were in persons who were consumers of water from the town service drawn from the river Gramont or from the Stainton Beck, above the intake of the borough supply. Dr. Robertson held that atmospheric conditions were intimately related to the fever prevalence; but Mr. Thompson, after full consideration given to the matter, inclined to the belief that the consumption of water from the sewage-polluted beck and river was the chief cause of the disease. I will not here speak of the gross pollutions to which these waterways were found to be subjected—excrementally and otherwise—since I shall have occasion to refer to the case of Penrith in a later portion of this report, where the facts will be found set out fully.

St. Luke, Middlesex (*County of London*).—Dr. Yarrow, in his annual report for 1893, relates the circumstances attending the occurrence of cases of typhoid fever in relation to the use of well water. The well in question has, some 20 feet distant, three waterclosets, a large urinal, and, nearer still, another watercloset, the only convenience for 67 persons in an adjacent works. The well serves a total of 84 persons. Professor Stokes was of opinion, after an analysis, that the water was polluted by surface drainage. Five cases in all arose in persons drinking of the water of the well, and having apparently no condition in common save drinking water; 4 of the patients were employed in the works just referred to. There would seem to be several wells in this parish, in situations not by any means such as to lend security to consumers of their contents.

The foregoing, then, are samples of the outbreaks which find no place in my appended summary. Not that I throw any doubt on the contention in the cases of these occurrences that they had casual relation with polluted water. But only that I have regard to the fact that the relationship has not seemed to have been made out with the same amount of convincing force as in other cases. It will, however, have served a useful purpose to have here reviewed the general outlines of reports illustrating the class of outbreaks which are excluded.

Tabulated Summary.

The outbreaks included in the appended summary tables number no fewer than 206, ranging from the year 1863 to the end of 1893. The outbreaks are very unevenly distributed in point of time, differing years showing vastly different numbers of separate epidemics caused by polluted waters. I have already stated that I have taken the year 1858 as my period of commencement, but there is no evidence of any outbreak thenceforward that I have come across in which water was the means by which typhoid was originated earlier than the year 1863 This is not to be understood as conveying my impression that no such occurrences happened; far from it; but only that they have not come within my cognisance. An analysis of the tables shows that in the 18 years 1871-76, 1879-84, and 1888-93, there occurred no fewer than 166 outbreaks out of the total noted; 69 in the first period, 58 in the second, and 39 in the third period. In these 18 years, then, 80 per cent. of the total number happened, the percentages in the respective subperiods being 33, 28, and 19 respectively. The entire period covered by the tables is 31 years. I have already explained my reason for drawing an arbitrary line at 1858, which has in reality become 1863, and with a view of illustrating the care taken to settle the then too little thought of matter of the origin of the spread of diseases by the medium of polluted water I here give two instances prior to that year in which, without doubt, drinking water played the leading part. The first I quote from the late Dr. Murchison's work on *Continued Fevers*:

"Richmond Terrace, Clifton, was a crescent composed of 34 houses. In 1847 the inhabitants of 13 of these houses drew their drinking water from a well at one end of the crescent. The remaining houses were supplied with water from another source. At the end of September it became evident, from the state and smell of the water from the pump, that it was tainted with sewage. Early in October 'intestinal fever' broke out nearly at once in all the 13 houses in which the tainted water had been drunk, but did not make its appearance in any of the other houses. In almost every one of the 13 houses 2 or 3 persons were laid up, and in some a much larger number. The houses in which the fever broke out were far apart in the terrace, and there was little or no intercourse between their inmates. The water from the well was the sole connecting link."

The second has reference to an outbreak reported by Dr. (now Sir Anthony) Home for the Privy Council Office, some years after its occurrence. The outbreak took place at Whitwick, in Leicestershire, in 1856, and occasioned 13 deaths. Only one street was invaded, all the residents drinking the water from one well which, on being opened, gave evidence, by a layer of soapsuds on the top, of leakage from an adjacent drain. The people were found to be literally "drinking fever;" and we are told that "the use of this water being interdicted, the fever disappeared."

Consideration of Tabulated Outbreaks.

In proceeding to treat of the several different, and indeed numerous, methods by which water has become the source and cause of spread of typhoid fever, it will be best to deal with typical instances of these methods. To this end the outbreaks are grouped under various headings, according as they were related to one or another class of cause. It may not be unwise to begin with a class all too common in rural districts, namely polluted wells. The outbreaks due to these death-dealing iniquities are neither few nor far between. Here are some typical examples.

Wellborne Outbreaks.

Shallow Wells near Dwellings.—A most clear case of waterborne typhoid was that of Page Green, Tottenham (No. 4), the water supply being, for some 30 houses, from shallow wells, sunk in a porous gravelly soil; the water in one well smelling distinctly of carbolic acid which had been poured down a yard sink. At Winterton (No. 7), the shallow wells were situate in the midst of all kinds of abominations, privies, ashpits, cesspools, and wells being in close proximity. "It is hardly possible," says Dr. Thorne Thorne, "to conceive conditions more favourable for its spread"—speaking of typhoid—"than those existing at Winterton." One can scarcely imagine a worse case than that of Stamford in 1868 (No. 10), where wells were sunk in a strata honeycombed with cesspools; "a subsoil in which the ordure of generations had been carefully stored up beneath the dwelling houses." A long continued outbreak was clearly traced to the consumption of the polluted contents of these filth traps. Perhaps one of the most glaring instances of persistent refusal to deal with a crying evil is that of the Rotherham Corporation in the matter of the Wellgate spring, situate as it is in the midst of the population of the borough. As long ago as 1863 the report of the Medical Officer to the Privy Council drew attention to the spring. In 1872 (No. 51) Dr. Ballard had to report an outbreak of typhoid in which this same spring played a part in disseminating the disease; whilst Dr. Theodore Thompson's report to the Local Government Board on an outbreak in the autumn of 1892 (No. 190) has called very special attention to this well. The water had been the subject of several analyses from 1886 to 1892. Every one gave indication of serious contamination; one at least pointed to "pollution by urine, cesspool drainage, or similar impurity," and this of a spring "in the centre of the borough," a town of 40,000 inhabitants. Towards the close of 1893 Dr. Klein made bacteriological examination of a sample of water from this well, and found the bacillus coli in abundance, as also a bacillus morphologically and culturally difficult to differentiate from the typhoid bacillus. Dr. Klein considered the spring open to excremental pollution; and the Corporation issued a warning that the water should be boiled before use. But what a pitiable spectacle does this case afford of local administration? Of the remaining sources of supply to Rotherham we shall have occasion to speak later. In the case of Worthing in 1886 (No. 124), we have an instance of a polluted well preferred to a public supply actually laid on to the house, and that house, moreover, a dairyman's premises. That the water became specifically contaminated by the discharges of a typhoid patient there can be little doubt. The excreta were thrown down the drains of a house from which soakage was finding its way to the well. Dr. Ballard paints a miserable picture of rural life in Newlyn in 1880 (No. 118), where the conditions as to excrement disposal and removal were disgraceful. On opening up the town well he found the level of the water therein and in the adjacent drain to be identical, whilst it was obvious that a free interchange of their contents had been for some time going on.

Dr. W. Brown, the health officer of Stapleton, mentions an interesting instance of well closure, the first in his district. He connected 9 cases of typhoid with use of the water, and Mr. Stoddart, the analyst, found in the water and succeeded in separating organisms which behaved almost precisely like the typhoid bacillus, though they were not typically morphological of that bacillus. Dr. Harrison, the health officer of the Lincoln rural district, in his annual report of 1893, says that of 78 samples of drinking water collected in the year, chiefly from wells, no fewer than 62 were polluted, whilst of 18 samples from one village not one was satisfactory. Dr. Kirkham, the health officer of the Downham rural district, in his report for 1893, says that it is next to impossible to insure purity of well water in the more thickly populated village while the pernicious midden system is in vogue. He speaks of these abominations as at times capacious holes dug in the back gardens, within a few yards of the well, and lined with loose brickwork.

Communicating Wells.—The danger of spread of typhoid by means of wells is seen to have a special significance where the local conditions are such that, given one polluted well, it follows as a matter of course that the specific particulate matter finds its way into other wells in the vicinity. That the danger is not purely imaginary may be seen from several instances in the appended tables; for example, at Sutton-in-Ashfield in 1872 (No. 42) typhoid was spread by means of pollution of tanks and wells situate at the higher end of the town; at Newark in 1884 (No. 153) the disease drew attention to the fact that those wells nearer the river were the more largely polluted; while at Greasbrough in 1893 (No. 203) the disease followed the line of the ground under conditions which pointed to primary contamination of the highest surface well, and certainly all the wells communicated.

Local Wells under differing Circumstances.—That wells need not necessarily be the cause of fever spread even when situate in insanitary places is evident from the experience of many localities. It is the manner of treating the actual structure and its immediate surroundings that in large measure determines the results of use of the water. For instance, at Donnington in 1871 (No. 26), wells, privies, pigstyes, and manure heaps were closely interrelated, and fever, introduced in 1868, remained an unwelcome visitor for some three years. But while fever attacked houses having wells so circumstanced and subject to no special care in the matter of protection from the entry of polluting media, houses adjacent to those invaded entirely escaped, owing to the careful manner in which their wells had been guarded from all possibility of contamination. An instance of the nastiness which some people will permit to find entry to their drinking water if they can, is that of a well at Bedale (No. 97) associated with an epidemic of typhoid in 1877. In the trough of the pump were washed all kinds of foul apparatus, including tools and barrows used in the emptying of middens, with resulting pollution of the well water, owing to stoppage of the stop drain of the pump.

Wells as Sources of Supply.—It will now, I think, have become evident that wells, as they are too frequently found in this country, are not by any means generally desirable as sources of drinking water; but there are wells and wells, and I would not be thought of as condemning all such sources. By no means; rather I have an opinion that wells properly situate and cared for and guarded form of all sources of water the best and most trustworthy. It is the hideous intermingling of excrement and water so often met with that is the chief ground of objection to these disease-disseminating holes. When the local conditions obtaining are such that they must needs cause excremental pollution of the ground around houses, then it is high time to close all wells sunk in the neighbourhood of the pollutions; and, indeed, not rarely will it be found expedient to do away with all wells for some distance around when the geological formation of the locality is such as to leave doubt as to the continuing safety of well waters. One can hardly pick up a report on the sanitary state of a rural district without reading of wells subject to pollution of one or another sort; or if by chance a district here and there is so fortunate as to have no wells liable to contamination, then it is generally one which, by means of past suffering through the consumption of polluted well water, has had the lesson of associated filth and disease so brought home as to have led to the adoption of measures of well-guarding as a sanitary necessity. Professor R. Koch, of Berlin, has given much care and thought to this important matter of wells in relation to their surroundings, and in his paper on "Water Filtration and Cholera," has indicated a way whereby wells may be so treated as relieve a district from the necessity of doing away with these handy and, if properly constructed, preferable sources of water supply. His remarks on the subject are so pertinent that I offer no apology for fully quoting him here.

"It will certainly not be easy to arrange that wells already in existence, even if badly constructed and dangerously situated, should be given up; but that is not always necessary. It will be comparatively easy in most cases so to alter the construction of the well as to remove all danger of contamination from above. It is only necessary to give to the well the same protection, or approximately the same protection, against contaminating percolations by means of filtering layers of soil such as exist in the case of a simple pump. To achieve this, one should proceed by filling the well up to the highest water point with gravel, and over the gravel with sand up to the very top. Here it is of course assumed that the well is already provided with an iron pipe, or, if this is not the case, that it will be provided with one before the gravel and sand are put in. In this way the well is turned into a pump, with the advantage over other ordinary pumps that its lower end dips into a layer which gives no resistance to the subsoil water. If it is proposed to keep the water supply of the well quantitatively intact, in order that, for instance, for purposes of extinguishing fires, a certain quantity of water should be at hand; there should then be erected above the highest point reached by the well water a construction of masonry or of iron capable of lifting the protecting sand covering; but the last should never be less than 2 metres deep. It is also to be recommended that the pump should not be erected immediately over the well, but some distance from it, and that it should be put into communication with the well by a lead pipe. This would prevent the water of the well, which when used for washing and other domestic purposes becomes foul, from leaking into the soil around. Wells protected in this or similar methods by good filtering layers, give the same protection against the infection of water as is given by the sand filtration of the great waterworks. In fact, they really give a greater protection, for they are not exposed to the many disturbances in the process of filtration......and are also not effected by frost. So much attention is now being given to perfecting as much as possible.the water supply of the great waterworks that it is important not to lose sight of the domestic water supply by pumps and wells. By improving the wells in the manner explained above, the spread of cholera, in so far as it is due to water, can be restricted to a great extent. It is just in this respect that a great deal can yet be done."

How far the advice here given can or should be followed I do not pretend to say. But it accords with the current belief that iron tubing of a depth sufficient to have insured its having passed through an impermeable layer into sand or gravel water-bearing strata will at any rate be a means of raising a water free from impurity at its source, since there is no system of filtration equal to that which is natural, and any resulting iron in the water so raised can soon be eliminated by a ready process of exposure and filtration.

I feel that having said so much I may now leave this matter of shallow wells and pass on to consider other ways by which water has played a part in the dissemination of typhoid fever. It will be, I think, convenient here to refer to the important feature of fissures as leading to water pollution.

Fissures and Typhoid Fever.

The existence of fissures is to be accounted for in many ways, as, for example, cracking of the ground by reason of excessive drought, subsidences, and the like. It will probably suffice if we give three instances in which fissures have seemed to have occasioned outbreaks of fever.

One is the case of New Herrington (No. 176), in 1889 where the connection of the fissure with pollution was quite accidental. The outbreak formed the subject of a report by the late Dr. David Page to the Local Government Board. Searching for any possible source of pollution of the well with which the disease had been associated, he found that owing to subsidences caused by colliery workings some fissures extended to a surface near a farmhouse about three-quarters of a mile distant from the well in question. He next found by an experiment carried out by means of a large quantity of salt that the fissures had connection with a staple feeding the well.

Thus he established the direct connection of the well and a farmhouse, though he could not demonstrate from what source the water derived its specific quality of infectiveness. But the existence of an underground "feeder" of the well was a revelation to the local authority.

Another notable instance of a fissure, this time in the Chalk, leading to a widespread dissemination of typhoid, was that of Worthing, in 1893 (No. 198*a*) where a well boring having been begun the attempt to get a supply to supplement the general service had to be abandoned on account of a large quantity of water met with but a short distance from the surface, and issuing from a fissure under circumstances such as appeared to point to the undesirability of using the water. Nevertheless, in 1893 the Town Council drove an adit from one of their wells, and oddly enough, met with the same stream of water at a depth of 72 feet, the inrush of water being so great that the men in the workings had to leave their tools and fly for their lives. Experiment with salt solution proved that the water thus struck was surface water, and that in its near vicinity there were leaky sewers which had been conveying the excreta of typhoid patients. The connection of the epidemic of typhoid with the water so obtained was established by Dr. Theodore Thomson in his elaborate report to the Local Government Board. I shall have to refer thereto at a later stage. A glaring instance of the potency of fissures for harm is that of Stamford in 1868 69 (No. 10), where cesspools were pouring their contents by way of fissures into wells situate at a lower level. The late Mr. Netten Radcliffe spoke in no measured terms of the state of the supply, but said that the town had a subsoil " in which the ordure of generations has been carefully stored up beneath the dwelling houses." Every well in the town was placed in dangerous proximity to sources of pollution. One can hardly credit the existence even a quarter of a century back of such a condition of things as that people should be found content to drink what was but a slightly diluted form of their own excrement. But although I have only thus lightly touched on the ability of fissures to cause pollution, it is not to be thought that I think lightly of their importance; rather I have a very clear conviction that they have a most significant bearing on the whole question of waterborne typhoid. One has but to look over the records of the tabular matter to get the impression that the relations of fissures and porosity of soil are together responsible for much disease dissemination. But I must leave the matter.

Adits in Relation to Typhoid Fever.

I may, however, perhaps very conveniently here refer to the closely related question of the influence of adits in spreading typhoid. These adjuncts to water service have been by no means free from blame in the history of waterborne fever, and it will be well to show, by a few references, in what way they have operated. In the case of Gunnislake (No. 82), in 1875, all the local conditions requisite to the spread of typhoid seem to have been present. The adit feeding a reservoir was driven in porous soil, and the ground had a steep gradient; added to these points was the fact of the occurrence of two cases of typhoid, the evacuations from which were thrown on a dust heap, the rain being excessive just prior to the general outburst; the water having undoubtedly become specifically fouled by these patient's excreta. Our second instance is somewhat out of the common, being the now historic case of Caterham (No. 102), where in 1879 a large epidemic was caused by specific contamination of the water service by reason of the purging in an adit of a workman who was suffering from typhoid fever. His motions are known to have been copious and frequent. A third case to which we may refer is that of Worthing (198 *a*), just mentioned in relation to its fissure. There was an adit that had been receiving the surface water and the contents of leaky sewers, and had not the Town Council driven the extra adit of 1893 in the very direction in which the well of 1885 had been dug with satisfactory results the town would no doubt have been spared the loss of many lives and the expenditure £10,000 towards the extinction of the typhoid epidemic of 1,400 cases. These instances suffice to direct attention to the importance of looking to it that adits are not driven indiscriminately and without having regard to the conformation of the ground above them. In future it is to be hoped that when any sudden rush of water is experienced in the course of driving an adit the source of the incoming water will be traced with exactitude, and that in every instance the geological circumstances of the locality will be minutely studied beforehand. In any case it is sincerely to be hoped that adits will never be made in the vicinity of any system of sewers. The case of Worthing illustrates the extreme danger of well water derived from a district on which are situate any aggregate of houses. Especially will this danger arise where the geological conditions are such that fissures are liable or likely to occur; as for instance on the Chalk formation.

Labourborne Typhoid Fever.

The instances in which the carelessness of workmen has led to serious spread of typhoid fever are by no means rare, and they may be considered as cases in which the disease as a waterborne fever should never have been heard of. I may quote two instances in which outbreaks have undoubtedly been caused by the medium of workmen, and one in which suspicion attached to this means as a method of spread. The first is the case of Eagley and Bolton in 1876 (No. 85) where fouling of a brook used for dairy purposes at a milk farm was brought about by the evacuations of workmen, there being abundant evidence of the use of the banks and bed of the brook for purposes of defæcation by individuals who had suffered from diarrhœal disorder suspicious of typhoid; this latter disease being subsequently spread by the milk from the dairy in question. The second instance is that of Caterham, previously mentioned, in the early part of 1879 (No. 102), where a workman in the workings fell ill of enteric fever whilst employed in an adit between two deep wells, and who specifically contaminated the workings by his frequent and copious evacuations. Upwards of 300 cases resulted, with 21 deaths. In the third instance, that of Worthing in 1893, and already referred to (No. 198 *a*), the health officer of the borough (Dr. Kelly) had in his possession evidence of the fouling of a new heading at the waterworks, and intimately connected with the epidemic, by workmen. Such excremental pollution as he knows to have taken place was regarded by him as perhaps accounting for the early manifestation of the disease, but no evidence was forthcoming as to any typhoidal illness among the workmen, though the entire absence of all mild attacks among them cannot, of course, be completely vouched for. But however this may have been, enough has doubtless been said to show what a serious matter it is to be depending on the good health and good conduct of men employed in workings having relation to water services. That the chance illness of one man can have as its consequence the amount of suffering and death which were caused in the first two instances referred to above is not a pleasant thought, and the difficulty of guarding against recurrences of a like sort is not the least unpleasant part about the matter. The past occurrences of this kind seem to call for serious notice at the hands of employers of labour in such undertakings as waterworks, with a view to the issuing of stringent instructions to the men that the calls of Nature are on no account to be obeyed except in places set apart for the purpose, and it should be the business of some sanitary official to see to it that such places are provided.

Water Contamination by Leaky Sewers.

The importance of having a sewerage system that shall be free from all defects of construction cannot be overestimated. The evil consequences attending the use of sewers that have been found on examination to be leaky have been on only too many occasions sadly evident. As illustrating this point I may refer to five instances shown in the tables to be published later. The cases quoted cover a large period of time, thus giving the idea that the dangers are potent to-day no less than a quarter of a century ago. At Guildford, in 1867 (No. 8), no condition other than water supply could be found which could be made to fit the circumstances of a fever prevalence which in its earlier manifestations attacked only those persons consuming water from one particular service. The curious part of the matter was that the houses affected were supplied for only one single day with the implicated water, that, namely, from a high-standing reservoir previously filled with water from a new well. This well was sunk through a porous stratum of Chalk in close proximity to various sewers one of which was found to leak in several places, almost certainly polluting the well. The second instance was no less curious than that just named. At Bramham College, near Tadcaster, in March, 1869 (No. 12), a large number of typhoid cases broke out simultaneously, most of them in abstainers. Inquiry as to the cause led to discovery that a drain that had carried the excreta of two imported cases of fever passed over a soft water tank, and that at this point it was throwing off its contents by way of a rat-hole, the contaminated water of the tank in turn leaking over on to the stonework of the adjacent well, which furnished the supply of drinking water to the College. An instance of a disgusting character was that of the Newlyn outbreak in 1880 (No 118), where all the early cases were in consumers of the water of the "town well," no other condition in common being discoverable. Between this well and a contiguous and solitary main drain there was free interchange of contents. Another circumstance that dubs this case as a bad one is the fact that the outbreak was kept from the knowledge of the community by order of the sanitary authority. A flagrant instance of gross insanitary conditions was that of Fareham, in 18[illegible]5 (No. 162), where in connection with a smart outbreak, numbering some 150 cases of typhoid, it was discovered that water mains and sewers were actually in direct relationship, whilst there was also equally unpardonable continuity existing between service pipes and watercloset pans; moreover, the water supply was intermittent. I shall in this place only give one more reference to the terrible results following upon the retention of leaky sewers, this last one being still fresh in the minds of most people. I refer to the epidemic at Worthing in 1893 (No. 198 *a*). Here, as has been already shown, the epidemic had close relation with a fissure in the Chalk, the fissure leading right down to a heading of water which had become specifically polluted, and had in turn contaminated the whole supply with which it was connected. The causal relationship of leaky sewers to the epidemic is most marked, seeing that the sudden multiplication of cases in early July is to be attributed with much probability to the pollution of the heading in question by the excreta of typhoid patients carried by defective and leaking drains on either side of the fissure. The cases in April, May, and June, the excreta from which would pass along these sewers, were by no means few in number, and the probability becomes almost certainty when we consider the circumstances around the rent in the Chalk into which these specifically contaminated sewers were able to disgorge parts of their contents in such a position as to render the pollution of the water much more than likely. The circumstances of this most unhappy outbreak are rendered the more regrettable when we remember that the retention in their place of old leaky, disused sewers played no unimportant part in the pollution of the ground around the fissured water-bearing strata in which the heading of 1893 was driven immediately below the spot where former attempts had demonstrated the presence of doubtful water.

Thus it is seen how great is the causal relationship of leaky sewers and waterborne typhoid. The lesson has been dearly taught that the utmost care is called for in the laying of sewers in the vicinity of either waterbearing soil or water mains. Not only, however, should care be exercised in the laying of sewers and drains, but where there is the slightest chance of the leakage of their contents finding a way to the water service, more than usual attention should be bestowed on those sections of the system. I shall have occasion to speak on this subject in connection with other outbreaks of a character not far removed from those of which I have been here treating, and where the sewerage has had much to do with fever prevalences.

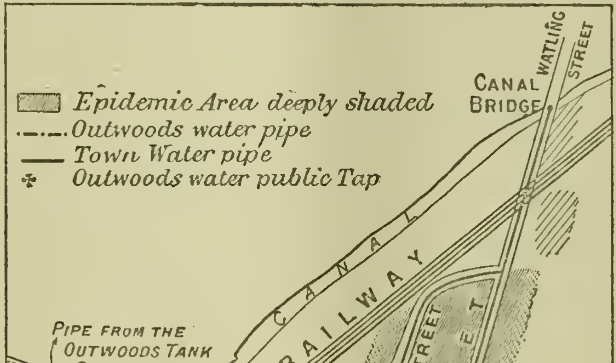
Ball Hydrants.

The use of these contrivances has more than once been deemed a likely means of disseminating disease, since in certain circumstances they allow free ingress to water mains of detritus from roadways. Indeed, any filth in the vicinity can gain access to the hydrant box, and, during periods of intermission of water service (when the ball would naturally fall), finds its way within the hydrant, to be sucked thence into the mains at the first opportunity. Dr. Franklin Parsons, of the Local Government Board, has discussed the theory of infection of water pipes which have been fitted with ball hydrants in his report on enteric fever which occurred in Cowpen in 1886-87, the report, however, only being made after the lapse of some four years, in 1890. He shows that there may well be danger in the use of such hydrants, as they are so arranged that with any loss of pressure in the main the ball must of necessity fall, when no obstacle remains to the ingress of either air or liquid into the pipes. The hydrant is a vertical branch pipe, containing a gutta-percha ball, which under ordinary circumstances is kept pressed by the water against an orifice surrounded with an india rubber seating, so that no water can escape nor air or water enter the pipes. In these conditions it is not to be wondered at that the lowering of that pressure on which depends the retention of the ball in its proper position should be a distinct danger. At Cowpen it seems not to have been a rare sight to witness the contents of ashpits—including night soil—standing over the iron boxes of the hydrants during periods of emptying these receptacles. Where the mains were laid with steep gradients there would be the greater danger of insuction of air and filth, the hydrants at the upper end of the main being in a position such as would favour the entry of liquid, etc., especially where, as in Cowpen, there was frequent lack of pressure of water service on account of shortness of supply. Dr. Parsons could not but think the danger a real one, and this had evidently been the thought of the local authority, since they had brought in the practice of sending round a man to see that all the hydrant boxes of any section to be turned off were clean. I have not included an account of this experience at Cowpen in my appended summary, as there was difference of opinion as to the exact cause of the outbreak. But I may well refer to the theory put forward in the case of the Worthing epidemic of 1893 (No. 198 *b*), where the action of ball hydrants was called in question as possibly elucidating the mystery attending the outburst of typhoid at West Worthing and West Tarring, where ball hydrants were in use on falling mains. Dr. Theodore Thomson, in his report, says that the boxes were often the receptacles of filth, which had gained access by way of the keyhole in the box. And he, by actual inspection, found that when the engines had for some hours ceased pumping, the majority of the balls had fallen, thus permitting the ingress of infective material from the roadways. But no positive evidence that contamination of water mains had thus been brought about could be found. Nevertheless, the danger is sufficiently appreciable to make it a point of insistance that no mains should be permitted to have affixed to them these undesirable apparatus. Worthing itself had retained them, notwithstanding that the health officer (Dr. Kelly) had in 1892 attributed a localised outbreak of typhoid to infection of mains in the same vicinity as was in question in 1893, through the instrumentality of these ball hydrants.

Water-main Levels and Typhoid Fever.

One can readily conceive that there are circumstances in which the question of levels of water mains would have a very important bearing on the incidence of fever distribution in a district which had been invaded by waterborne typhoid. This point has been already referred to in commenting on the outbreak at Worthing of 1893 (No. 198 *b*), where the disease in its incidence on West Worthing and West Tarring fastened on those portions which laid low in relation to the water mains. The theory held there, and generally in respect of localised outbreaks of a like nature, is that any material gaining access to the uncharged water mains would, as a matter of course, gravitate to their lower levels. That this theory is a tenable one no one would care to deny. But there is another way in which the levels of waterpipes are seen to have a probable causal relationship with typhoid, and that is that only one section of a water service may be polluted, and that this particular section may, on account of the level of the distributing reservoir, be capable of distribution in only a circumscribed area of the district served by it and other sources of water. That the case here supposed is not a mere hypothesis is seen from a consideration of the circumstances attending the outbreak of typhoid at Atherstone in 1893 (No. 199), where the disease was related to the contamination of one section only of the public water service. That the outbreak was one of a waterborne character leaves no opportunity for question if the data be looked to, and that one portion of the service was implicated is also amply demonstrated by the figures which Dr. Wheaton, of the Local Government Board, is able to adduce in favour of this thesis. Of the circumstances leading to contamination of the particular water I shall have to speak in other connection, suffice it here that the contamination was fully made out and that we have now merely to consider the part played by the means of distribution of the water.

Looking to the interest attaching to this outbreak I have introduced a reduced plan of the district affected from Dr. Wheaton's report, with a view of leading to a better understanding of the bearing of the levels of the epidemic area to the outbreak. The portion of the plan shaded most deeply constitutes the "epidemic area," and lies at the lowest levels. The implicated ("Outwoods") water ran in the pipe terminating at the Greek cross at the junction of South Street and Station Street. During the time of chief epidemic manifestation of the disease this water was nightly turned into the mains by being joined to the remaining pipe in the Coleshill Road, the other "town" water service being nightly turned off on account of fear of water famine if it were allowed to be constantly flowing to the distributing mains. In these circumstances and in view of the large amount of water used by the residents of this portion of the town, there would be almost no water in the mains when the implicated "Outwoods" water was turned into the pipes each evening.



Rough Plan of the Town of Atherstone showing the Main Streets and Water Mains

Now the levels of the district are such that this "Outwoods" water on admission to the mains would flow first of all to the district north of the Greek cross, namely, down Station Street, under the railway to a dead end at the foot of the canal bridge at Watling Street and along the northern half of Long Street back to Coleshill Street and thence to its original starting place. The levels respectively of the Atherstone mains and of the source of the Outwoods water were such that little if any of the water thus admitted from Outwoods could, having regard to the pressure, reach the district south of Coleshill Street. In respect of these two districts thus naturally formed for purposes of water distribution Dr. Wheaton says that the difference of level between the dead ends of the two was seven feet.

"Water could therefore circulate round the northern loop when the pressure would not suffice to enable it to circulate round the southern loop......If the whole system of mains were supposed to be completely emptied, and a small body of water then turned at low pressure into the main leading from the reservoir, the water would fill the whole of the northern loop, including the long main ending in a 'dead end,' before any of it would pass into the southern loop." The local surveyor was of opinion that the pressure was never such as to carry the Outwoods water into the mains in the south-western portion of the district. The locality, being inhabited by people who in the nature of their occupation had to rise early, was one in which they would, in drawing off water at an early hour, be more likely to draw off the Outwoods water than persons residing in other parts of the town. And in addition, as in some way perhaps showing cause for undue prevalence of typhoid in this locality, the residents had the fountain at the Greek cross to which to resort for this same Outwoods water. The season during which this water was nightly turned into the mains was but a short one, but while it lasted no less than 93 per cent. of the numerous cases arising occurred within this epidemic area; in the next four weeks as many as 83 per cent. so occurred. There was a special incidence on adult males. The evidence here given seems to me to be pretty conclusive of the potency for harm, within the special area of epidemicity, of the contents of the low lying water mains, whilst the configuration of the ground saved the closely adjacent streets from sharing the same fate. But yet another factor in the continuance of the fever in this same northern low-lying section of the town has to be considered. It is that the specific poison having been admitted to the mains may have become multiplied in the long pipe ending in a "dead end" at the canal bridge. At a point where the dip of the pipe takes it under the railway the depression is such that the accumulated water is perhaps never wholly drawn off, the germ of the disease increasing in the stagnant water, to be distributed every time the water newly admitted into the main came in contact with the stagnating contents, constant mixing of the waters at this point leading to contamination equally constant. Here, indeed, we learn that the water from the main was entirely disused on account of its having a nasty taste, so that any direct evidence as to this theory cannot be found. But it is a feasible one.

It is easily to be conceived that when water was rapidly drawn from the mains, some of the stagnant water from this depression could be in this way drawn into the loop supplying the epidemic area and consumed there. That the circumstances of this most interesting occurrence of typhoid fever at Atherstone afford indication of a special danger attaching to low lying localities at the periphery of a water source, when specifically contaminated water is distributed thereto, admits to my mind of no doubt. The incidence of fever on low-lying streets thus circumstanced both in this case and that of West Worthing and West Tarring having been so ably described by Drs. Wheaton and Thomson, should lead sanitary officers, when incidence of a like nature comes within their ken, to ascertain whether water may not be concerned as a medium of cause and spread, and whether the local conditions are such as to have led either to gravitation, with chance of subsequent stagnation, of infective material to the lower levels of the distributing mains, or to the gravitation of water already possessed of infective quality to the low level terminal pipes, and to these alone. The matter will arise in the next heading treated.

Insuction of Air, etc., into Water Mains.

There can be no question of the vast amount of harm to health caused in time past by the action of imperfect water mains and pipes in admitting morbific material both during intermissions of water service and when running "full." The possibility of the entry of such material when intermission of water was known to have occurred was never much doubted, if indeed it ever was doubted; but the theory that mains running full could also act as means for conducting outside material by lateral insuction has not been held as proven for very long. It is the knowledge of the now well-established fact that pipes incur this danger even when the normal water pressure is maintained that gives especial significance to the operation of such a subtle foe to the health and life of man. We now know that when water is passing through a pipe with great velocity, where there is greatest velocity there will be a partial vacuum; and if the pipe chance to be placed in communication with the outer air—whether by accident or otherwise—there will ensue strong insuction; the greater the flow of water the greater being the power of insuction. Sir George Buchanan has well set forth the aspects of the case in its relation to disease causation in the following words: Speaking of indraught of material having occurred through apertures in the sides of pipes running full, he said: "(1) The lateral incurrent is freely produced when the water pipe is descending and when the pipe below the hole is unobstructed; (2) if the force of waterflow in a descending pipe be moderate, a moderate degree of obstruction below the hole does not prevent the incurrent; (3) in horizontal pipes of uniform calibre, when the flow is strong, or the pipe beyond the hole is long or when the end of the pipe is at all turned upwards, the incurrent does not take place; but (4) momentary interference with flow, *a tergo*, or momentary reduction of obstruction, *a fronte*, allows a momentary incurrent through the hole; (5) incurrent through a lateral hole takes place with incomparably greater ease when the hole is made at a point of constriction of the water pipe."

I have now to refer to some of the principal instances in which the insuction of morbific material into water pipes has been found to have direct causal relationship with outbreaks of typhoid fever. The case to which I would first direct attention is that of the historic outbreak at Sherborne in early 1873 (No. 55), investigated by Dr. Blaxall on behalf of the Local Government Board. Here it was found, after careful study of the facts, that the disease had been caused by insuction of air into the service pipes from closet pans during intermissions of water supply, typhoid fever being present already in the town. There was sudden appearance of the fever, after a nightly intermission of the service in the month preceding this epidemic manifestation. During the whole prevalence the ratio of attack on houses on the particular water service was 29 per cent., as compared with only 7 on the other services. The lesson taught by this invasion of the town was not learned in vain, as the sanitary authority set to work to repair the defects brought to light, and the direct communication between water pipes and closets was generally cut off. But that the work had not been thorough was unfortunately shown by the occurrence of cases of typhoid under identical conditions in 1882 (No. 135). That this later manifestation was limited as it was may fairly be referred to the activity of the sanitary authority in the matter in the intervening years. The outbreak was confined to four houses, or rather three of four houses, having one condition in common, namely, direct connection of closet pans and water pipes. Now the sewers of Sherborne had been already open to infection by the excreta of antecedent typhoid cases. The direct connections in these houses seemed the only ones remaining in the town so far as I can gather. There were ten attacks in the three (school) houses invaded, the fourth, escaping, house being inhabited by adults only, and these non-water drinkers, all those attacked being, on the other hand, water drinkers.

My next illustration is that of Hull in 1874 (No. 73), when and where a very large number of typhoid cases arose in circumstances which led to confident assumption of drain air as the cause of the epidemic. Dr. King, the investigator, had his attention drawn to the vast amount of air expelled from the waterpipes on the opening of some of the taps, this air at times smelling offensively. The smell of the water was also complained of as it left the mains. This air was, Dr. King felt convinced, drawn into the mains in their course along the streets in close proximity to the sewers. He had every reason to believe that both foul air and foul matters had ample facility of entry to the pipes and mains. The water service was especially intermittent about the time of the epidemic. In the case of Over Darwen in the same year, 1874 (No. 75), there was widespread disaster through the faulty construction of a water conduit. Upwards of 2,000 attacks were heard of all classes being affected. The particular way in which contamination of water was brought about was by entrance to a water conduit, having imperfectly secured joints, of the contents of a watercloset drain of defective construction and choked condition, such contents consisting partly of excreta from an imported case of typhoid. The suddenness and universality of the epidemic is shown by the fact that some 1,500 cases came under treatment within a space of three weeks. At Tideswell, in Derbyshire, in 1876, Dr. Thorne Thorne chronicles a small outbreak (No. 86), caused by insuction of specifically fouled air into a small water main by means of an open tap leading from a closet pan in which the excreta of two typhoid patients had been cast. The last illustration which I need give in this connection is that of the well known epidemic at Mountain Ash in 1887 (No. 165), and which was so fully investigated by the late Mr. John Spear. From July to October 518 cases were recorded, 31 proving fatal, and 88 per cent. of the attacks being among consumers of the public water supply. Of 391 houses supplied from a particular main below a defective joint, to be referred to later on, 57 per cent. were invaded. In the "epidemic area" drawing water from this main, 88 per cent. of cases occurred, against 12 per cent. in adjacent localities. Moreover, there were many who, having suffered outside the epidemic area, nevertheless contracted the disease within that area. The evidence which Mr. Spear brings forward in support of his contention that the epidemic was due to contamination of water mains is both strong and plentiful. I need not here follow every step of the way by which he ultimately arrived at the conclusion that the mischief must lie within a very narrow compass; nor need I reproduce all the data which go to fortify his thesis. Suffice it that by very careful inquiry and logical reasoning Mr. Spear eliminated all known causes of typhoid other than water; and by close study of the facts as they were seen to arise in relation to water and fever as cause and effect, he soon saw that the "epidemic area" was limited to a most circumscribed portion of the district. Having found that the area was thus limited, he set to work to discover the particular factor acting as the *verâ causa* of the epidemic. Mr. Spear established the point that the factor in question was a polluted water main—the Oxford Street main—and further that the commencement of the second 160 yards of this main was the place at which fever infection, gaining access to the water, would avail to produce an incidence of fever upon houses such as actually showed itself. "It was almost permissible to hope," says Mr. Spear, in view of the evidence adduced, "that one could have foretold the very spot at which to find a defect in the Oxford Street main permitting the entry of specific contamination." There were, however, difficulties in the way of such precision. The Oxford Street main was relaid in 1885, in a very careless manner: mostly at night, and by private contract. "Accordingly the main was carried, without any special precaution, immediately above, alongside, and even through, old rubble drains; and when, in the course of the trenching, pipe drains were cut through, no trouble appears to have been taken to replace them." In this main, and that of Henry Street adjoining, leakage was discovered at ten different places. As one result of the careless laying of the Oxford Street main, it was at different points from time to time bathed in refuse matters; and habitually, at certain points, in sewage-contaminated air. For the rest, I quote further from Mr. Spear's report:

"At any time of intermission it is plain that the leaky water pipes were at liberty to discharge their contents through any opening at a lower level, and that they would convey, not only such water as remained in them, but those matters also which entered at the points of leakage. In short, the leaky pipes would act as so many means of draining the ground in which they were placed. Passing through or alongside old rubble culverts they would take up foul air and liquid from these culverts and from the soil around, and would deliver these matters at low levels (if not during intermission, on the first renewal of supply) for consumption as 'drinking water.' Intermission of water current, however, is not by any means essential to the introduction of foreign matters into water pipes. Under various physical conditions very powerful insuction of external matters into a full flowing water pipe can take place. Some of these conditions were considered in a departmental report on Croydon in 1875 But the fact of this lateral insuction into water pipes 'running full' is not universally known, and certainly is not known as it ought to be to many of the engineers who undertake the responsible business of laying water mains and other water pipes. The circumstances of the Oxford Street main are such as would appear to well fulfil a number of the conditions productive of lateral incurrents during the continuance of general water flow. It is a descending pipe from its commencement to some 120 yards below Oxford Street; there it is carried in, in full diameter, to large colliery workings, where for the purpose of supplying boilers, locomotives, etc., it has been the custom to take from time to time very large draughts of water. Again at the commencement of the main, a twin branch (6 inch) from Pryce Street is given off to join the system on the other side of the river. Usually, I am assured, no flow of water occurs through this pipe, but under circumstances leading to diminished supply or larger consumption on the Caegarrow side, it would be, perhaps, suddenly fully drawn upon. It results from the foregoing observations that during intermissions of the service, large contamination of the water of the Oxford Street and Henry Street mains must have occurred, and that contamination, although on a comparatively minute scale, during continuance of supply is probable. Chemical analysis of the water, and still more microscopical examination, afford important confirmatory results. Dr. Dupré, to whom samples were sent for analysis, reports that water taken from a house tap in Henry Street, before the nightly intermission of service, was pure, while that from the same tap after intermission gives evidence of animal contamination and of the appearance of low forms of life. Water from a tap in Victoria Street (Miskin) showed similardeterioration both in the night and morning supplies."

Cesspool Polluted Water.

One might be quite sure that such abominations as cesspools would not be without evidence as being the means of causing pollution of water and consequent disease. If I quote only one instance it is not because there are none other that I could refer to, but only that the example is one of far-reaching harm wrought by one leaky cesspool. That cesspools, of whatever construction, should be allowed to persist is bad enough, but that leaky contrivances, whose chief aim seems to be to rid themselves of their contents, should be permitted to be made is a blot on our sanitary escutcheon. I am well aware, of course, that the question may be asked, What is to be done where sewers are not available, and where houses are not aggregated together in any number? I would make answer, At the worst construct a cesspool that is water-tight, and such that its contents shall be easily capable of being emptied at short intervals. But in the case of the outbreak of typhoid at Tolcarne, near Newquay, Cornwall, in 1879 (No. 104), a cesspool had been built in a loose soil, and not only so, but was in a leaky and altogether ill constructed condition. So situate was the well that served the terrace of houses making use of this cesspool that the contents of the latter soaked into the well; the residents were therefore virtually drinking their excrement in a diluted form! In this outbreak 18 cases occurred in three houses, 12 out of 18 persons being attacked in one house. It is no wonder that the model by-laws of the Local Government Board which have relation to the construction of cesspools should be of their present strict nature; and it will be well when those authorities who feel unable altogether to discard cesspools shall have not only adopted such by-laws, but determine to enforce them.

Frost and Thaw in Relation to Typhoid Fever.

That such factors as frost and thaw should have any direct bearing on waterborne typhoid seems, perhaps, at first sight unlikely; but a closer study of the subject will soon show that these are very important factors in the spread of fever. I can best demonstrate this by reference to instances in which they have seemed to play a part. The first case to which I make reference is Malpas (No. 27), where in February of 1871 a case of typhoid fever proved fatal while a hard frost was prevailing. So severe was the frost that no water could be obtained from the works. But soon after a thaw set in "the sewage-irrigated surface of the fields was thawed, and the inhabitants began to drink water just adulterated with the pent up sewage of weeks," probably infected by human excrement. A month after the first fatal case the disease suddenly broke out in all parts of the village. Only those, however, obtaining water from the lower portion of the village were attacked, their supply being taken after it had been conducted through sewage-polluted meadows. School children from outside who were attacked were both consumers of the implicated water and users of the infected school privy. A very remarkable outbreak was that at Crosshill, in 1875, the village of Eaglesham also being involved (No. 76), and one in which a hard frost and subsequent thaw both had part—the first as a retarder of the prevalence and the latter as the means of rapid spread of the fever. The facts are as follow:

Typhoid attacked the inmates of a farm in November during hard frost which lasted some five weeks. The stools of at least twenty patients from adjacent houses invaded a month later were cast into privies which drained—as did also a dung-stead in the farmyard—towards a streamlet forming the water supply of another dairy. The houses just mentioned got their fever undoubtedly from use of water from two wells which caught the soakage of the infected dung-stead at the farm first invaded. Whilst the privies thus infected by the typhoid excreta remained frost-bound no harm followed this disposal of the dejecta; but when the frost broke and the accumulated privy contents were swept into the streamlet, then fever began to quickly assume ugly proportions in the consumers of the milk of the dairy making use of this specifically poisoned water. Of 262 families using the implicated milk of two farms which had a polluted water supply, no fewer than 94 were invaded, against only 18 of 242 other families, and of these 18 no fewer than 10 occasionally partook of the milk in question. The area covered by the outbreak was somewhat wide.

Much later we have the case of the fever outbreak at King's Lynn (No. 189), to which I shall have occasion to refer again in other connection, and where typhoid excreta from a series of patients were cast during frost upon a garden, and were carried down by heavy rainfall and melting snow to the river Gaywood which flowed at the bottom of the garden in question. The water supply is drawn from the river, which thus received the specific poison of typhoid. The outbreak was of vast proportions, and was preceded by much diarrhœa, the data leaving no doubt as to the epidemic being of waterborne origin.

The lesson to be taught by these occurrences is that, though frost may seem to make safe action which would be considered unsafe in ordinary times—such as the throwing of excreta on privies and the like—yet that the germs of typhoid are as actively potent for harm after endurance through a time of exposure to the agency of frost as though they had been newly cast on the receptacles, from which they have to be ejected later by the action of heavy rains and the accompanying thaw. The further lesson should be learned that all excreta should be properly treated ere they are disposed of anywhere. Only as lately as 1893 Dr. Bruce Low, investigating an outbreak of typhoid fever in the urban district of Shildon and East Thickley, in co. Durham, had occasion to refer to the practice of throwing the dejecta of patients on to privy middens in an untreated form, as having contributed to the spread of the disease. And, apart from the action of thaw following frost in regard of privy middens thus specifically infected, there is the further danger of the poisoning of food supplies in adjacent larders and living rooms by the effluvia from these filth receptacles; one instance of milk infection, with consequent spread of typhoid among the customers of the dairy, being much commented on by Dr. Bruce Low in the very report to which I have just alluded.

Rain Storms in Relation to Typhoid Fever.

Near akin to the matter just left is this of rain storms, since it frequently happens that a thaw is accompanied by rains, helping the more quickly to cause the germs of disease to travel over the ground in the direction of water supplies. That rain storms have been very potent factors in the spread of typhoid I shall be able to show by a few references to out breaks which have resulted as a corollary of their occurrence. At Nunney, in Somersetshire (No. 43), Dr. Ballard made inquiry into an outbreak of typhoid in 1872, which was the result of carelessly deposited excreta from an imported case, and from others which followed in the house. Heavy rains came which had as their consequence the washing into a brook of the excreta in question, the brook forming the source of water supply. Actual excrement from patients was finding its way into the brook for several months half a mile above the village. With the carting of good water to the village the disease soon disappeared. At Armley, in 1872 (No. 44), a well used by a dairy was sunk in a porous soil, and so as to favour pollution by sewage matter. Evacuations from a case of typhoid at the farm were thrown on to the dung heap; and after copious rains, such as would render easy the percolation of infective material to the water, the fever began to operate, ceasing, so far as customers of the dairy were concerned, a fortnight after the pump handle was chained up. In the same year, at Hucknall Torkard, where typhoid was endemic (No 45), the disease became suddenly epidemic after rain storms which washed the contents of privies and middens into the wells and streams whence the water supply was drawn. True the people were also breathing impure air and living in damp houses. My last reference has to do with an outbreak seven years later in Alcester (No. 105), investigated by Dr. G. H. Fosbroke, the health officer. In August heavy floods caused washing of foul matters from privies and the like into the already polluted subsoil wells. Indeed, the privies and wells were alike overflowed by rains. Consumers of the public water service escaped, all the cases being in well users. The danger to shallow wells here depicted must ever remain while methods of excrement such as have been described are permitted to obtain. Whilst people harbour filth in the near vicinity of dwellings and at the same time draw water from surface wells quite closely adjacent to the filth receptacles referred to, the resulting intermingling of contents must ever be a factor to be considered in tracing out the cause of disease prevalences in places thus circumstanced. People must not expect to utilise two neighbouring holes, the one as a cesspool and the other as a well, with impunity, or without sooner or later having to pay a heavy price for the uncleanly proceeding.

Sewage Disposal in Relation to Typhoid Fever.

The problem of how to dispose of sewage in such manner that it shall not cause nuisance or pollute waterways has long been a difficult one for sanitary authorities successfully to solve. More especially does the question abound with difficulties in places far removed from tidal waterways. As a rule, sea coast towns have little trouble as to how to get rid of their liquid sewage, since tides favour the means of innocuous disposal of the sewer contents. Time and again has the disposal of sewage in situations dangerous to water supplies been the cause of typhoid outbreaks.

As instancing the way in which sewage effluent has led to the spread of enteric fever, I refer to the cases of Lewes and Beverley. In the first-named place, Lewes (No. 71), Dr. Thorne Thorne made inquiry on behalf of the Local Government Board into an outbreak, comprising 486 cases, which had several features of importance. First of all the prevalence was the indirect result of the accidental action of some children in leaving open the tidal valve of an inlet pipe under circumstances now to be described. The sewage of Lewes was poured into the river Ouse. This river, polluted as it thus was, had tidal relations with a stream which was at times used as a supplementary source of water supply for the town. Now the inlet pipe to which was affixed the valve, which had been playfully left open, was that which admitted water from this Ouse-polluted stream, and the time at which the valve had thus been left unprotected was one of such tidal conditions as allowed of free ingress of water from this stream. A fortnight later typhoid suddenly broke out in consumers of the public water service, and despite other causes of spread when the disease had fastened on the town, there were no less than 80 per cent. of attacks in consumers of this water from August to October. And it seems certain that other sufferers, who habitually drank well water, also at some time before the attack, partook of the public service.

The second instance, that of Beverley, was of a different class, having reference to the disposal of the sewage of an institution on land not far from the town well (No. 152). The sewage was disposed of by irrigation at irregular intervals, the field thus treated being contiguous to both well and reservoir. Cases of typhoid had occurred in the institution, and it is held that the specific poison of the disease had been carried with the sewage over the field and thus into the well. The evacuations of the patients were thrown untreated down the waterclosets draining to the field in question. The outbreak in the town was both sudden and widespread, 66 of the first 68 persons attacked being consumers of the water from the well near the sewage field. The evidence against the well water was most conclusive, and the means by which it acquired its poisonous quality admit of but little doubt.

Here, then, in these two instances of differing methods of sewage disposal we have examples of the way in which dangerous conditions may arise through the water carriage system in our towns. The whole subject of sewage disposal is much too large to be discussed here, but it may be laid down as a rule which should never be departed from that all sewage disposal works should be so far away as to render them absolutely harmless to any water supply that may be in their neighbourhood, gathering grounds being specially held in mind in determining upon the spot at which the disposal shall take place. The law, indeed, in this respect seems to be open to much improvement, since as matters stand it appears to be within the province of a sanitary authority to carry out works of sewage disposal on the gathering grounds of adjacent districts and to do such things with their sewage as may distinctly endanger the contents of reservoirs and the like. This power should be removed and that speedily.

Polluted Subsoil Water.

That water levels in the subsoils have had much to do with pollution of water services there is ample evidence to demonstrably show. On looking through my tables I have had little trouble in picking out excellent examples of the results of the action of these underground waters having found their way into wells and such like sources of domestic supply, carrying with them that which has set typhoid going in a district by the score of cases and with many deaths. I here give reference to some half-dozen outbreaks related to subsoil waters, dealing with them in chronological order.

At Terling, in Essex (No. 9), typhoid lasted from December, 1867, to March, 1868, 300 attacks taking place, with 41 deaths. The village was one of which Dr. Thorne Thorne had to report that much diluted foul material had evidently long been washing into wells, which were everywhere of a shallow nature and subject to contamination. Typhoid was endemic in the place. A drought had lowered the water levels; but only to be followed by a sudden great rise in the levels as the result of melting snow and the like after heavy frost, Terling being the only village in the neighbourhood with such a sudden rise, and the only village invaded by typhoid. The rise showed that the wells had become the receptacles of the washings of the filth-sodden soil. Equally as sudden as the rise of the subsoil water was the increase of fever, and the relation of well water and the disease as cause and effect was strongly marked. The grouping of cases around certain wells was a feature in the epidemic. Sir George Buchanan has told how, in the village of Wicken Bonant, also in Essex (No. 15), there was relation of well and brook in the matter of water levels and turbidity, with chance of specific pollution of the well by way of the brook owing to the disposal in a privy close to its waters of the untreated evacuations of an imported typhoid case only some 30 yards above the well, the water in the well and brook, moreover, rising and falling together in times of flood and drought. That the epidemic which followed this imported case was one caused by the water of the public well thus exposed to pollution is amply demonstrated by the data which are given in the appendix, where this outbreak finds mention.

At Hugglescote and Donnington, in 1871 (No. 26), a prevalence was caused by the pollution of wells sunk in a sandy loam largely mixed with gravel. The disease was introduced in May, 1868, and had ever since been endemic, there having, however, been intervals of freedom. The disease was always set agoing by the inter-relations of excrement disposal and wells. Dr. Home, reporting on the occurrence for the Privy Council Office, thought of the intervals of freedom as probably having relation with the dilution by rainfall of the infective material which would under other conditions have caused epidemic spread of typhoid. Lowness of wells, coupled with intense heat, seemed most favourable to spread of the disease. Ten years later an outbreak at Dartford, in Kent (No. 127), has much interest for us in regard to water levels. The soil in which the local wells were sunk was excrementally polluted, and pumping operations undertaken in 1880 in connection with sewer laying in the lower portions of the district had resulted in lowering the subsoil water, and in draining away the liquid contents of cesspools which abounded. As a further result, wells became contaminated by the entrance of fresh water through the soil thus fouled by the escaped contents of the filthy cesspools, disturbed by the pumping in question. The original case of typhoid led to specific fouling of one of the local wells. The outbreak which followed on the pumping was almost confined to the district thus disturbed. The last case to which I refer in this connection is that of the Hants County Lunatic Asylum at Fareham, in 1888 (No. 171), the institution having a model sewerage system and its own water service. The well from which the water is drawn had in its near vicinity some leaky drains, and the pumping for purposes of drawing water influenced the level of the underground water far beyond the polluting media of the neighbouring cemetery and sewage farm, from the direction of which the subsoil water comes. Here, then, in these five samples of the relation of subsoil water and typhoid fever we have evidence of the potency of such water for harm. Where, as in too many places is still the case, the wells and cesspools remain in close proximity, the movements of subsoil water are an important feature in the sanitary condition of the locality. In soils which readily permit of soakage, the intermingling of the contents of the wells and cesspools will not long be a matter of uncertainty. Such intermingling of filth and water cannot be continued without grave risk of definite disease becoming endemic, if not at times epidemic. We have seen that intervals may occur in which water-spread disease seems to have been eradicated, but only to break out afresh at a later stage, and, it may well be, with renewed virulence. Only too many of our towns are built on sites which have been subject to excremental pollution for very many years, and which, having to act at once as excremental and water-bearing strata, are well situated as disease disseminators. It will be well when people cease to draw water from the near vicinity of aggregated dwellings, especially when a water-carriage system of sewage disposal is wanting. Diluted excrement may be drunk without the consequence of specific disease only so long as specific poison of the subsoil and the water it carries is not brought about. But the penalty of living amid filthy surroundings must be paid sooner or later.

Drainage from Farmsteads and Manured Fields.

It is nearly thirty years since the eyes of sanitarians began to open to the fact that danger to the public health was arising by reason of the drainage of manured fields being carried into town water supplies. The use of night soil for manurial purposes was just then coming into more general use, and the consequences of this agricultural proceeding were also becoming apparent in the nature of waterborne outbreaks of typhoid. In 1865, 20 deaths from this disease occurred in a rural parish near St. Neots, Hunts (No. 6), through which parish ran a brook, the water of which was used for drinking purposes. Within the space of three miles of its course this brook received the drainage of three farmsteads and that of manured fields. The majority of attacks originated in cottages making use of the brook for domestic water supply.

Another instance in which the drainage of manured fields did much to spread typhoid was that of Hebden Bridge in 1884 (No. 155), the water system there having become polluted by such drainage from fields overspread by excreta of human and animal origin. A heavy rainfall just antecedent to the outbreak assisted in carrying with it a large amount of filth to the cisterns situate at various heights on the slope of a valley, and fed by springs in the hill above. At a higher part of the hillside, but near the springs and channels leading to the cisterns, were not only manured meadows, but also privy pits and manure heaps, showing drainage towards the water troughs. The water sources here in question were found fault with a few years later by the late Dr. David Page, when inquiring into a prevalence of enteric fever in the village of Mytholmroyd in the neighbourhood, the Hebden Bridge and Midgley divisions of this then (sanitarily speaking) much-divided village being principally referred to in this connection. I quote from his report.

"Small streams descending the hillsides are the chief local sources of water supply. None of these can be said to be safe from contamination by washings from meadows and manured lands, and of some there is manifest exposure to gross pollution by excremental filth. This is notably the case of the chief local supply on the north side of the village in Hebden Bridge and Midgley divisions. The water is conveyed in pipes from a so-called spring on the hillside, issuing from beneath the meadow land of a farm at a higher level. At this farm a strong flow of water issuing from underneath the manure heap and receiving its drainage was, at the time of my visit, irrigating the meadows in question, upon the surface of which it ultimately disappeared. The farmer pointed out that occasionally the flow of water was diverted and turned through the farm buildings and a common privy for the purpose of washing out their contents upon the meadows, and he explained that by diverting it altogether from the field, the volume of water at the spring below became seriously diminished. Another local source is a spout in a yard adjoining the White Lion Inn in Midgley division. Its gathering ground is in meadow land on the other side of Rochdale Canal, under which it is conveyed in a conduit of unknown material to the spout. It was formerly exposed to pollution from a midden privy said to have been placed on the line of pipe, and at the present time there is a midden privy within 6 feet of it. An analysis made in January last warrants the analyst in describing a particular sample of this water as having the characteristics of a good and pure drinking water."

A very flagrant case of the use of water exposed to manurial drainage came to light so recently as 1886, having been discovered by Dr. Franklin Parsons, of the Local Government Board, when inspecting the urban district of Ashton-in-Makerfield. Despite his warning to the sanitary authority, Dr. Wheaton, visiting the same district in 1893 in relation to a prevalence of enteric fever, had occasion to report as follows:

"The water is derived entirely from the surface drainage of cultivated land. In 1886 Dr. Parsons, one of the Board's Medical Inspectors, found that parts of the gathering ground were manured with the contents of the privies and middens of the district, and drew the attention of the sanitary authority to the dangers arising from this practice. Incredible as it may seem, the practice of manuring parts of the gathering ground with privy manure from the district was continued, and this material had been applied to the land, even in the immediate neighbourhood of the reservoir, up to the middle of 1892; so that there could be no doubt that surface water from fields manured in this way obtained entry to the reservoir. Since the onset of the fever, however, the use of manure of any sort on the land in the neighbourhood of the reservoir has been discontinued and none has been disposed of in this way since July, 1892."

But the fact remains that a practice so foul and dangerous as is here reported on was allowed to persist with the full knowledge and consent of the so-called local "health authority."

But this part of my report would not be complete if I did not advert to the still more flagrant instance, if possible, of the town of Penrith, reported on by Dr. Bruce Low for the same Board in 1893, in connection with an outbreak of typhoid fever, most probably waterborne, in 1891, and to which I have already made passing reference in my short account of outbreaks of doubtful causation. From this town a petition had reached the Local Government Board in which some 200 residents complained of the defective state of the water supply, and not without cause. Time and again the matter had been brought before the sanitary authority, but with little avail. I cannot do better than quote what was said on the subject of Dr. Low's report in the BRITISH MEDICAL JOURNAL at the time of issue of the document. The JOURNAL of May 12th, 1894, in commenting on the report, said: "The supply is taken from the river Eamont, about three-quarters of a mile from the town, and within the borough itself. It is pumped without filtration to the town, first passing down the village street to the pumping station in pipes through the village, laid in duplicate and extremely defective and leaky, having in their near neighbourhood eleven privies, slop water pipes, dung heaps, etc., the subsoil, moreover, being of a porous gravelly nature. And we read that when the intake pipe is closed there can still be pumped a considerable quantity of water, pointing to insuction of the contaminated subsoil water. The river is subjected to many and gross pollutions in its course of five miles from the lake of Ulleswater, for we read of the discharge of crude sewage from the villages of Pooley Bridge, Yanwath, Dacre, Stainton, and others; whilst scattered houses and heavily manured fields add their quota. But perhaps the most revolting instance is that of a farm on the fields of which is spread at times the sludge from the settling tanks of the Penrith sewage outfall works. This sludge consists largely of human excrement, which in times of flood or heavy thaw can be washed into the drinking water, and thus furnish an instance of the economy of Nature which the people of Penrith never, we are sure, had in contemplation." Dr. Low goes on to state that, notwithstanding this disgraceful condition of affairs, the sanitary authority were content to go on patching up this dangerous river supply instead of going in for an extraneous service safe from the risks to which the present supply must ever expose the town. The consequences of the importation of cholera into Penrith, and the discharge into the sewers and thence into the settling tanks of the evacuations of cholera patients, are not pleasant to dwell upon. Sludge spread on the drainage areas of the river under such circumstances would endanger the whole place, and might not unlikely lead to widespread infection, for the land on which sludge has hitherto been spread is only a mile above the intake, and specific pollution of the town supply is to be thought of as more than probable granted the presence of the germs of Asiatic cholera in the sludge in question. Here, then, is a town situate in the heart of England's choicest scenery, happy in possessing a water supply which would be condemned in any dirty Continental town. Not deeming it sufficient to draw its water from a river exposed to numerous kinds of pollution more or less outside the jurisdiction of the sanitary body charged with safeguarding the public health, the people, or most of them, have been satisfied to drink water which has, it may be, at times been no other than a weak solution of their own excrement.

These and many other like instances to which I might refer only give prominence to the idea which I have long put forward that county councils should have very full and definite powers in respect of water supplies. That water should be allowed to be served to a community from a source obviously in danger of contamination is monstrous, and should not for one moment be tolerated. Yet the matter is of only too common occurrence. Every year but adds to the already long list of epidemics of preventable disease caused by the agency of water supplies open to the polluting media of manured fields, sewage-fed streams, etc. The history of waterborne typhoid, as detailed in the appended tabular statement, is largely a record of extreme neglect on the part of health bodies here, there, and everywhere. If local interests are not sufficiently strong to prevent the continuous running after the cheap and nasty insanitary "sanitation"—so-called—then it is high time that some other authority were empowered to step in and take the reins of sanitary government.

I do not limit myself to the matter of water supplies in this way; but I must not further digress from my subject. I have, I trust, shown the extreme necessity of careful attention to the mode of disposal of sewage and town refuse in relation to water services, and the harm that has accrued in the past for want of such attention.

DILUTED EXCRETA AS WATER SUPPLIES.

I have in the last heading covered much of the ground to be examined in connection with the subject of the influence of diluted excrement in spreading typhoid. Thus I have referred to Penrith, just dealt with, and to the glaring instance of Ashton-in Makerfield. But there remain other cases to which I would like to invite closer attention than is given by mere mention in the appendix. At Annesley, for example, where 100 cases arose in 1870 (No. 19), Sir George Buchanan has told us in so many words that the people "drink their own excrement," there being a row of 40 privies kept dry by soakage of contents, and in the porous soil a well sunk beneath them from which the houses chiefly affected procured their water. The further distant the houses from the privies, and having other wells, the less did they suffer. Again, at Basingstoke, where there was an epidemic in 1871 (No. 30), Dr. Ballard tells us that excrement and water supply were so intimately associated that "throughout the town people are unwittingly drinking their own excrement." Wells were sunk in a cesspool-riddled soil with surface water seen at times standing in the cesspits. Wells supplying the village of Burton Latimer (No 41), in 1872 were so circumstanced that non-pollution would have been little short of a miracle; and the first of some 250 cases of typhoid which occurred was on premises where the well was within 20 feet of a hole into which slops were thrown. In the case of the Bristol Lunatic Asylum (No. 66), diluted sewage had for years been used with impunity in the absence of specific poison; but with the advent of fever attacks the water thus sewage-laden acquired a new property and typhoid ensued. In the instance of an outbreak at the Glasgow Hospitals in 1884 (No. 154), evidence was forthcoming to the effect that cattle had been rendered ill by the consumption of water which contained sewage products in a large degree. It was milk from these cattle that had seemed to give rise to the disease, typhoid fever, which occurred in the hospitals to the number of 104 cases.

Moreover, the epidemic at the villages at which the cattle drank of the polluted water is regarded by Dr. Milroy, of Kilwinning, as the result of contamination of the pump well by manure from Glasgow itself, such manure being thought of as likely to have contained the germs of typhoid. Temporary disuse of the pump water led to cessation of the fever; but its re-use was followed by an epidemic manifestation of the disease, 10 per cent. of the 1,000 residents suffering fever in two years. It certainly is a disgrace to our country that such conditions have been found to persist at quite recent date; the like having been made matter of comment many years back, and under circumstances which one would have thought would have led to State action of a sort to prevent recurrence of filthinesses so disgusting as those referred to in the excellent series of reports of Sir John Simon to the Privy Council, and especially that for the year 1873 (ii) in connection with the subject of filth diseases. Were England administered from a sanitary point of view in the manner in which her position in the world of sanitarians demands, there would be a speedy weeding out of authorities whose chief aim in their corporate existence seems to be to see how little they can possible spend on matters of public benefit from a health standpoint. That such bodies should be permitted to live is a mistake; nothing quickens a lax authority so much as being threatened with annihilation, and nothing is to be thought of as so calculated to arouse some of our recalcitrant authorities to sanitary activity as the knowledge that continued inaction will bring about their dissolution. Excrement is a matter with which every sanitary body will have to do, and the sooner the community learn that the safe disposal of this commodity is one of vital moment for the sake of the public health, the sooner will the ever recurring instances of epidemic spread of disease on account of pollution of drinking water by inattention to this question cease to be heard of. And the community must be taught ere they can learn; and they can only be taught by those who have been themselves imbued with the notions which it is desirable thus to inculcate in others. So here, again, I would see drastic action taken where the elementary principles of cause and effect are neglected, and where the persistent bringing into close association of the disease-provoking excrement and the domestic water supply is regarded with equanimity bordering on criminal negligence.

Riverborne Typhoid Fever.

The part played by rivers in the dissemination of typhoid fever has been increasingly frequent in the mind of sanitarians of late years. The matter of water supplies as derived from English rivers is one of very great importance, seeing how many of our towns are dependent on the water ways for their domestic supplies The subject is one to which I must give some little amount of space, having regard to the fact that it is and has been a bone of contention as to whether rivers can give rise to typhoid epidemics in the way with which they have been credited by some experts in sanitary circles. Leaving the contentious portion of the subject to a later page, let us here first of all look at the evidence forthcoming from a perusal of the appended tabular statement on the general question of river pollution in relation to typhoid outbreaks, in so far as localised occurrences seem to be in the position of effect from such pollution. Passing in review some of the cases of this sort, I shall leave for further and more detailed discussion the historic Tees Valley epidemics of 1890 91. The first case to which I refer is that of the outbreaks of 1882 83, as Hitchin (No. 145), which Mr. W. H. Power investigated for the Local Government Board, and which had as cause the pollution of the river Hiz, so-called by courtesy more than right, since it is described as "hardly more than a ditch." The pumping station had as a defect the means whereby backflow of water could at times take place from the river, the latter receiving the excremental refuse from houses on its banks. There was precedent to each of the outbursts a flood, with consequent opportunity for the backflow of river water into the contents of the pumping station. All causes other than water could be excluded and only those persons consuming the public supply suffered under the disease, well water drinkers escaping, except in a few instances where opportunity had been given for partial use of the implicated service. I may conveniently speak of the next two instances at once in view of the fact that they were both of them outbreaks related to use of the same river, namely, the Trent. They are the cases of the Gainsborough rural district (No. 174), and of the town of Newark (No. 180), the disease in the first named having lingered at least during the period January, 1889, to June, 1893, and in the latter from January, 1890, to June, 1893; these periods being those for which it was possible to obtain accurate details of the attacks occurring. The river Trent is subject to such gross pollution that I really think I may be pardoned if I quote from the report on the outbreaks which was made by Dr. Bruce Low for the Local Government Board, where he especially refers to the condition of the river. He says:

"Almost from its source the Trent becomes polluted with sewage. The river and several of its tributaries constitute the natural drainage of nearly the whole of Staffordshire. In its passage through the densely-populated Pottery district the Trent is admittedly polluted, and lower down the crude sewage of many places, as well as the effluents from sewage farms, mingle with the waters of the Trent and its tributaries. Taking two tributaries as samples of the others, the Tame—which receives sewage from Birmingham, more especially at times of heavy rainfall, and from the Black Country—is highly polluted; and lower down, the Derwent, which flows through the centre of Derbyshire to the Trent, receives the crude sewage of such places as Bakewell, Matlock Bridge, Matlock Bath, Belper, Derby, Alvaston and Boulton, having a combined population of nearly 120,000. The sewage of Nottingham is disposed of upon land adjoining the Trent at Burton Joyce, about five miles from the town and about eighteen miles above Newark. The effluent, owing to the care which has been and is being taken with the preparation of the land used as a sewage farm, is, under ordinary circumstances, clear and free from objectionable smell. But in times of heavy rainfall it is found necessary to turn the contents of the flooded sewers of Nottingham direct into the Trent. In this and other ways much untreated sewage at times reaches the river. Still lower down the crude sewage of Newark passes directly into the Trent, and farther down still the town of Gainsborough discharges its sewage into the river. In addition to the towns last mentioned, the whole of the intervening places on the river drain into the Trent without any attempt at purification of their sewage. Into the lower section of the river, with which this report is more especially concerned, there is drained a considerable area of heavily-manured land; so that after heavy rains the river is contaminated by the washing into it of more or less towns' manure and night soil imported from large urban districts. The town of Nottingham, for example, where the pail system is still in use, has to dispose of more than 1,000 tons of night soil every week. Much of it is taken by boats to neighbouring districts, the natural drainage of which is to the river. Such manure would be liable at any time to contain the bowel discharges of enteric fever patients and of persons suffering from diarrhœa."

This short statement very succinctly lays before the reader the gross state of this river, and will lead him to be less sceptical, even if previously disposed so to be, as to the relations of the waterway with disease in those persons compelled to drink of its waters. Not, however, that compulsion has entered solely into the matter, since Dr. Low tells us of a sneaking affection for the river water on the part of riverside dwellers. He relates how one "enthusiastic admirer of Trent water in a riverside village after drawing a pailful of water from the river to fill his teakettle......found solid fæces in the pail." I need hardly say that the disuse of the river followed as a matter of course. For the rest I quote from a notice of the report in the Journal of March 10th, 1894:

"On the subject of fever prevalence in association with Trent water, Dr. Low's facts, briefly stated, are as follows: In the Gainsborough rural sanitary district in the four years and a-half ended June, 1893, there were 192 known cases of fever, of which 167 occurred in 10 villages, with 5 700 inhabitants, using mainly water from the Trent or Chesterfield canal, the latter being also grossly polluted. There were only 25 cases in 51 villages, with over 13 000 people, using well water. The respective attack rates were 29 and 2 per 1 000 living. Of the 25 cases, 4 may be deducted as imported, and other 2 as probable users of Trent water. In Newark, of 53 cases of fever in 1890, 73 per cent. used the public water services; of 125 cases in 1891, the percentage was 91; of 69 cases in 1892, it was 68; and of 50 cases in the first half of 1893, 82 per cent. used the public supply; the percentage of sufferers doing so being 78 5 in the whole period of 3½ years. The public service here in question was from wells and culverts on the banks of the Trent subject to admixture by the river water. All other probable causes of fever could be eliminated."

An instance of more gross pollution can scarcely be imagined. The data above given are to my mind convincing that here we have to deal with a riverborne disease, and be it kept in mind that the locality—the Trent valley—in which these conditions have been found to be prevailing is one inhabited by half a million souls. The matter is worse when we learn, as we do from Dr. Low, that sand and gravel are taken from the river between Newark and Gainsborough for renewal of the filtering materials of some public water supplies. "Unless," says Dr. Low, "previous to use they are subjected to careful preparation, such materials might themselves become a source of danger." Especially does he think of danger in the not unlikely event of cholera importation into the Trent valley, previous visitations of the disease having hit the Trentsiders rather heavily. To another instance allusion has already been made in other connection—namely, that of King's Lynn (No. 189). I need not here refer to the data in support of the contention that the epidemic of typhoid from which that town suffered in 1891-92 was waterborne. Nor need I again set out the circumstances (which are detailed in the Appendix) in which the outburst of fever was brought about. Let it suffice to state that the river Gaywood was the recipient of much polluting media, and that the specific poison of enteric fever was shown to have had opportunity of ingress to the river just prior to an outbreak of diarrhœa, which was in turn rapidly succeeded by the graver malady. The great lesson to be derived from this unhappy experience of King's Lynn, after that of the folly of taking drinking water from a polluted river, is the persistence with which the town council of the borough refused to listen to competent advice to leave the river and seek otherwhere a supply free from risk of danger. It is only after this bitter demonstration of the evils of delay that the sanitary authority have seen fit to move in the matter. In all such matters delays are indeed dangerous. But the instance of riverborne typhoid round which most interest has of late centred is that of the Tees valley, to which I have recently made reference (No. 182), and which demands a full description, since so much depends on the way in which this case comes ultimately to be looked at by sanitary experts. I will therefore at the outset quote the brief summary of the case inserted in the British Medical Journal of November 4th, 1893, whilst I at the same time reproduce two illustrations from the report which give some idea of the state of the river banks at two places.

"Two distinct epidemic prevalences are treated, each of six weeks' duration, the first from September 7th to October 18th, 1890, the second from December 28th, 1890, to February 7th, 1891. The whole area dealt with is one of 706,020 acres, or 1,103 square miles, containing half a million people in ten registration districts, comprising thirty-two separate sanitary areas. In the two epidemics 1 463 cases of enteric fever were heard of, and 1,334 or 91 per cent., occurred among a population of just over 250,000 persons, situate in three of the ten registration districts, the rates of attack per 10.000 being 29 and 24 respectively in the two epidemics, against 3.5 and 1 5 in the remaining seven districts, with a population almost identical in point of numbers. In the matter of fever deaths this special area had rates three and five times greater than the other seven districts. In regard of sanitary areas, it was found that of the 32 only 10 had excess of attack rate, 9 of these being in the special area just referred to, 8 being urban and 2 rural districts. Of the 1,463 known attacks, 1,352, or 92 per cent., occurred in these ten districts, with rates per 10,000 of population of 31 to 3 and 26 to 1 as compared with the other 22 districts in the two epidemics. Judged either by attack- or death rates, the exceptional incidence on this special area was heaviest in the second epidemic, at a season when enteric fever is not apt to be prevalent in this country. Dr. Barry enters at great length into the statistical data here briefly summarised, and, by an excellent series of maps, follows the course of the disease, fortnight by fortnight, in the invaded district as a whole and in certain towns in particular. Dr. Barry likewise deals very fully with the sanitary circumstances of the special area, and, whilst he lays bare some glaring insanitary conditions, which call loudly for remedial action, he has been unable to find any community of sanitary circumstance other than water supply. But in this important element he found the ten excessively-invaded districts in common, in that all drank of Tees water distributed, after a process of sand filtration, through the works of the Darlington Corporation or the Stockton and Middlesbrough Water Board. This water was laid on to 39 566 houses (all but 447 in the special area), having 219 435 inhabitants, out of the total of 93,974 houses, with 503,616 inhabitants in the gross area. On the 219,435 persons consuming Tees water the attack rates per 10 000 were 33 and 28 in the two epidemics, in the 284,181 persons drinking other water the rates were 3 and 1. Combining the two epidemic periods, 15 persons drinking Tees water were attacked for each unit of the remaining population. (See in this connection the accompanying chart.) It is difficult to read Dr. Barry's description of the pollutions to which the River Tees is subject above the water intakes, and to believe that people have been content to consume its waters. This portion of the report is illustrated by a series of plates consisting of reproduced photographs revealing some of the 'stinking abominations' along the banks of this 'common sewer' and 'public scavenger.' We read of some twenty villages and hamlets, and of the town of Barnard Castle, draining to the river; of washings of highly manured lands, drainage of graveyards and farmhouses, of privies, urinals, waterclosets along the foreshore; of 'loads of stinking refuse,' ashes, midden refuse, gasworks refuse, and other accumulations of filth aiding the pollution of the river, especially in times of flood. So long ago as 1875 the river was known to be polluted, on the evidence of the present manager of the Water Board referred to; fifteen years later expert evidence pointed to the 'disgusting and offensive' state of the Tees; and bacteriological examinations of its waters in 1887 gave indication of 'profound sewage contamination' of this river, which had been held up to scorn as in 'a disgraceful state of pollution.'

"Looking to the amount, character, and sources of the filth finding its way to the Tees, and also to the numerous opportunities which are known to have occurred for specific contamination of the river by the poison of enteric fever, it needed only times of flood, coincident with the periods of disease prevalence, to give reasonable explanation of the two outbursts. These floods actually took place, the epidemic periods being preceded, the one by a 'much flooded' condition of the river due to excessive rainfall, and the second by 'an 8-foot flood,' due to melting snow. 'Seldom, if ever,' says Dr. Thorne Thorne, in concluding his introduction to the report, 'has a case of the fouling of water intended for human consumption, so gross or persistently maintained, come within the cognisance of the Medical Department; and seldom, if ever, has the proof of the relation of the use of water so befouled to wholesale occurrence of enteric fever been more obvious and patent.'"

Such, in the very briefest of forms, is the evidence which Dr. Barry has to show in support of his contention that the typhoid prevalences in the Tees valley were each and both caused by the consumption of water from the river. Had there been those found who were disposed to quarrel with the conclusion at which Dr. Barry arrives, I should have been astonished; my astonishment then when it became known that a Royal Commission on the subject of the water supply of London had been unable to come to any definite view in the matter can be better imagined than described. Yet such is the case, since the Royal Commission on Metropolitan Water Supply have reported themselves as not able to decide as between Dr. Barry and his official supporters, with an abundance of substantial evidence, on the one hand, and the expression of his opinions by the representative of the Stockton and Middlesbrough Water Board, who gave evidence before the Commission on behalf of his Board, on the other hand, his contention being that the disease which had prevailed in the Tees valley was not Teesborne, but was dependent on other conditions than water for its cause and spread. I make no apology for large quotations from the report of the Commission on this most important question of the relation of the Tees water to the typhoid outbreaks which called for Dr. Barry's investigation. The subject, apart from its interest in this particular instance, is one of vast concern for the public health, seeing that the inability of the Commission is not unlikely to do harm to sanitary progress by standing in the way of securing that water supplies taken from water ways open to pollution be looked upon as distinctly dangerous to the consumers. Let us, then, turn to the report of the Commission, and see what they have to say on this Tees report.

First of all they state in regard of the "evidence of experience" that enteric fever, equally with cholera, can be communicated from person to person by the medium of drinking water. This much they admit as proven. So far good: but when they come to deal with this local case of the Tees, their unqualified statement on the matter of drinking water is found to have been considerably modified in respect of drinking water that is also river water. Here is their report on Dr. Barry's volumes:

"In 1890 a serious outbreak of enteric fever occurred in the Tees valley, and was attributed to Dr. Barry, the medical inspector, in a report published in the supplement to the Twentieth Annual Report of the Local Government Board, 1890-91, to the consumption of water taken from the Tees, and delivered after filtration by the Darlington Corporation and Stockton and Middlesbrough Water Board. This view he further upheld in a later and fuller report, which will appear in the supplement to the Twenty-first Annual Report of the Local Government Board, in continuation of the report of the medical officer for 1891, and of which we were favoured with advance copies; and in this final report he extended his inquiries to a second outbreak in the year 1891, and assigned to this an origin in the Tees water supply.

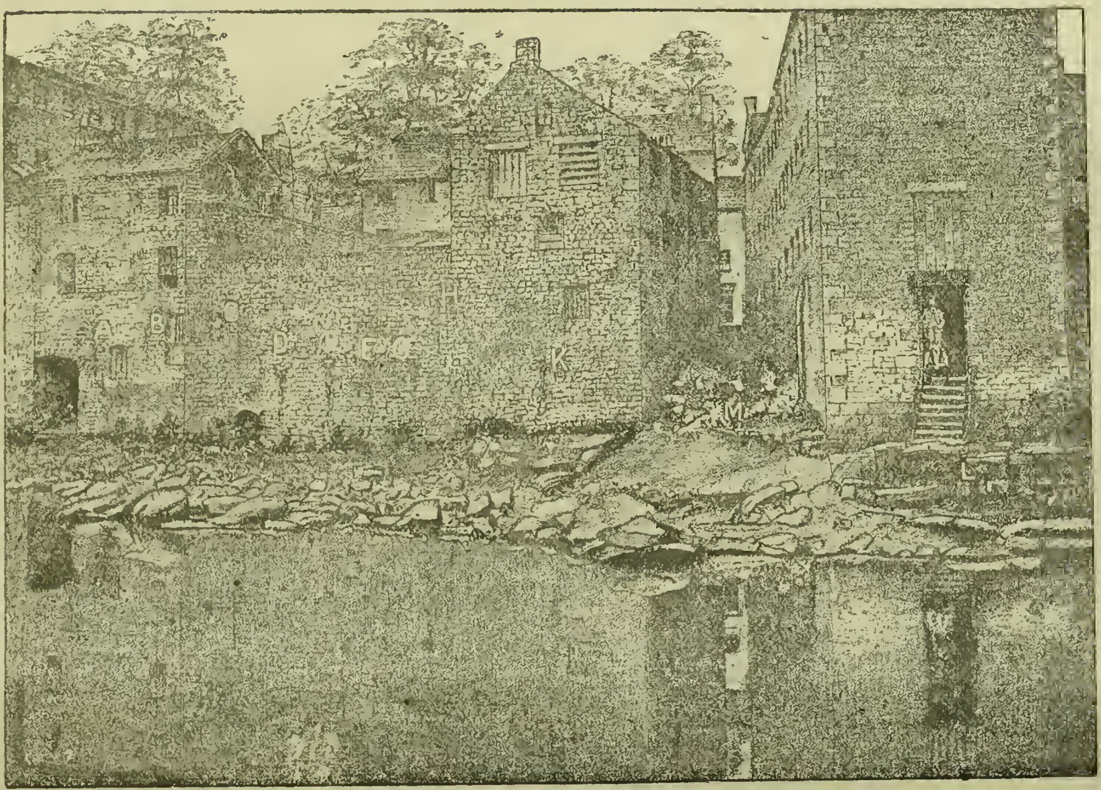


Fig. 1. View of foreshore of river Tees at the end of Kitchen's Lane, Barnard Castle. A and B, house drains; C, privy; D, E, F, G, yard drains; H, privy; K, drain from cowhouse; L, slop drain; M, tip composed of house and midden refuse.

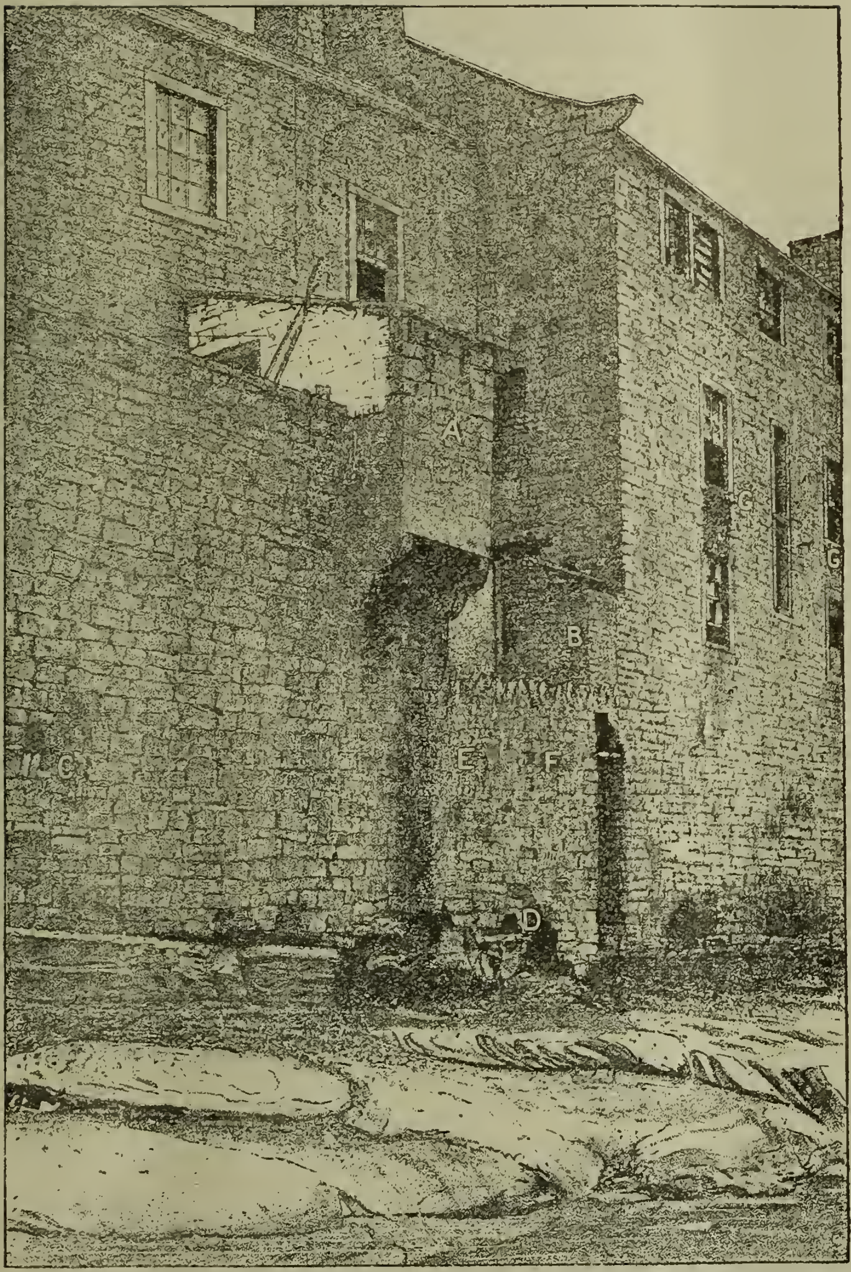


Fig. 2. View showing back of houses abutting on foreshore of river Tees north of Barnard Castle Bridge, Bridge End, Startforth. A, privy serving four houses; B, privy serving one house; C, D, E, F, yard and foundation drains; G, windows through which excrement and ashes are discharged from houses unprovided with drains, privies, or ashpits.

"The conclusion at which Dr. Barry arrived in regard to the 1890 outbreak, to which we have more especially directed our attention, appears to have been based on the following propositions:

(*a*) That the fever was so vastly more prevalent in the districts supplied with Tees water than the districts supplied with other sources, that it may be said to have been practically confined to them.

(*b*) That the attacks were spread over all the districts supplied with Tees water with very great, though not, of course, with mathematically perfect uniformity; and that the several districts were attacked simultaneously.

(*c*) That, water supply apart, there was no other difference of any importance between the Tees-drinking and the other districts.

(*d*) That there was an accumulation of filth upon the banks of the Tees at places above the intake, and notably at Barnard Castle, and that a flood which happened on August 13th, 1890, must necessarily have washed this filth into the river; and that the time when the outbreak declared itself, after allowing for the incubation period, tallied with the view that the outbreak was caused by this pollution.

"This series of propositions doubtless constitutes a formidable indictment against the water supply. They are, however, one and all traversed by Mr. Wilson, the representative of the Stockton and Middlesbrough Water Board, and the chief objections that can be made to them severally may be stated as follows:—

As regards the proposition lettered (*a*) it is admitted, speaking generally, that the fever was much more prevalent in the Tees drinking than in the surrounding districts; but it is said that the difference in this respect between the two was very much smaller than represented by the inspector, inasmuch as notification of cases was compulsory in the former with the exception of one sanitary district out of ten, while it was voluntary in the latter, with the exception of seven sanitary districts out of twenty-two; and that in consequence of this the number of cases was largely overstated in the Tees-drinking districts, and largely understated in the other districts; and in support of this appeal is made to the respective case mortalities, as deduced from the inspector's own tables.

To the proposition lettered (*b*) it is answered that not only did numerous villages or hamlets that were supplied with Tees water altogether escape, but that, in districts which were attacked, the attacks were not spread with uniformity over the area, but occurred, either exclusively or preferentially, in certain parts, and that this distribution coincided with marked difference in the sewerage arrangements, which were so faulty that previous outbreaks of fever had been attributed to them by official inspectors, and the probability of further outbreaks asserted.

To the proposition lettered (*c*) it is answered that the water supply does not constitute the only important difference between the two sets of districts; that the Tees-drinking districts are almost exclusively urban, and the other districts almost exclusively rural; and that if the thirty two sanitary districts dealt with in Dr. Barry's report be divided into urban and rural, without regard to their water supply, it is found that the reported fever cases were four or five times as numerous in the urban as in the rural group; and that the conditions of urban life, with its common sewerage and its closer aggregation of inhabitants, are notoriously more favourable to the diffusion of disease than are the conditions of rural life.

To the proposition lettered (*d*) it is replied that, though the flood of August 13th must have washed down such filth as was on the banks, that filth can only have been such as had accumulated since the next preceding heavy flood, which was on July 1st; and that in this interval there had been no traceable case of enteric fever in the area above the intake; and that consequently the filth cannot have contained the specific poison which is essential for the production of enteric fever, and that the suggestion that there may have been cases of fever unknown to the medical men above the intake is a perfectly unsupported hypothesis.

"Dr. Barry, as we understand him, admits with some qualifications the truth of these criticisms, but maintains that, when all due allowance has been made for them, there remains a body of evidence which they are not weighty enough to counterbalance, and which, though it does not actually demonstrate, constitutes a strong presumption that the explanation of the outbreak adopted by him was the true one.

"We felt strongly that without very minute and accurate acquaintance with the locality, and without much more elaborate knowledge of the complicated circumstance of this and previous outbreaks of fever in the Tees valley than it was practically possible for us to acquire, it was out of the question that we should decide between these conflicting opinions. Although, therefore, we have printed the evidence put before us concerning this outbreak, and have attempted to sum up as fairly as we could the main arguments on either side, we refrain from expressing any judgment as to its origin. This much, however, we may say: that the pollution on a given day of a river like the Tees, with a flow in time of flood of at least 1,000,000,000 gallons in the twenty-four hours, by what must at most have been a very small amount of active enteric poison, at a point 17 miles above the intake, should so seriously affect the water that the admission of a certain limited amount of it into the reservoirs should produce, notwithstanding filtration, an extensive outbreak lasting for some six weeks, is a hypothesis so startling and so entirely unsupported by previous experience in other places, that it is fair to demand the most conclusive evidence before accepting it as proven; and, though we attach great importance to the opinion of such an experienced inspector as Dr. Barry, we cannot say that such conclusive evidence has, in our opinion, been brought before us."

In giving this lengthy extract my only regret is that I cannot reproduce both the evidence on which it is based and, as well, the full report which gave rise to the criticism. I must admit my surprise at the failure of the Commission to state clearly their opinion on the question at issue, namely, whether or not the Tees water did in fact cause the enteric fever attributed to its consumption. The columns of the British Medical Journal of January 20th, 1894, considered the objections of the Commission to Dr. Barry's thesis, and I cannot do better than repeat what was there said, with such slight modification of the actual text as is called for by lapse of time:

"In their summary of the Tees report the Commission omit two important points, the confirmation of the attack-rates by the mortality-rates, and the almost identical behaviour of two successive epidemics. The rest are said to have been 'traversed' by Mr. Wilson. He admits, it seems, that the fever was much more prevalent in the Tees-drinking than in the surrounding districts, but alleges that the difference has been exaggerated owing to the incomparability of attack-rates in notification and non-notification areas, and points to the unequal case mortalities in the two divisions, as shown by Dr. Barry's tables. In large water epidemics the case mortality is usually low, Caterham and Mountain Ash being notable instances, and it seems probable that Mr. Wilson is here unintentionally pointing out a circumstance tending to confirm the water hypothesis. Broadly speaking, the attack-rates were confirmed by the death-rates, and in a footnote to Dr. Thorne Thorne's introduction to the Tees Report (page 7) it is mentioned that in notification districts partially supplied with Tees water the attack-rate among 8,991 Tees-drinkers was 89 per 10 000, and among the other 14,442 inhabitants only 6 2. Mr. Wilson's next point is that some villages and hamlets supplied with Tees water escaped, and that the incidence coincided with faulty sewerage arrangements. If he is to be understood as referring merely to a few minor instances the objection has no weight, but if it is suggested that the localities stricken by the two epidemics were as clearly and uniformly marked out from the rest by exceptionally bad drainage as they were by their exceptional water supply, we have direct conflict of evidence between Dr. Barry and Mr. Wilson in a matter upon which the Commission could surely have satisfied themselves without much difficulty. In any case the neglect of drainage affords no security against water epidemics.

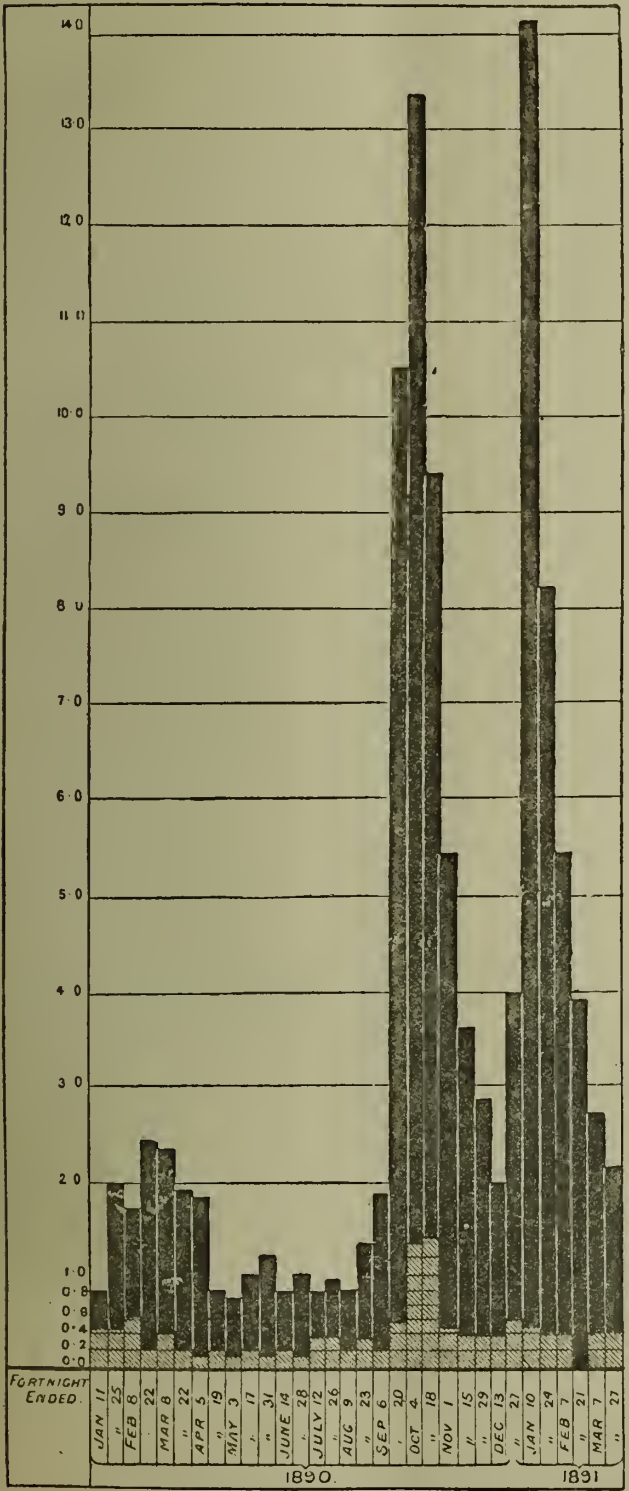


Fig. 3 Enteric fever attacks, fortnight by fortnight, per 10,000 living. The attack-rates among Tees drinkers are shown by black columns, and the corresponding rates among the rest of the population by lighter squares inserted in the former.

"The Commission represent Mr. Wilson as advancing a curious argument in his reply to proposition lettered (*c*). In regard of this it is difficult to conceive how the difference of nomenclature can be supposed to account for the enormous difference in incidence of fever. It is true that enteric fever in general affects town more than country, but that is not quite the same thing as affecting all urban sanitary districts more than rural sanitary districts, nor is the difference of sufficient magnitude to account for a quarter of the disparity with which we are now dealing. Dr. Barry's point is that, taking the several districts either individually or collectively, rural as well as urban, the epidemics attacked and killed a far greater proportion of the Tees-drinkers than of the rest of the population. Moreover, community of water supply is one of the conditions which occasionally contribute largely to the incidence of enteric fever upon the dwellers in towns.

"Mr. Wilson's fourth and last point is that the flood of August 13th could only wash down such filth as had accumulated since the previous flood on July 1st, and that there is no proof of any case of enteric fever having occurred above the intake in the interval. Elsewhere he has urged that in the absence of compulsory notification the records are incomplete, and the Act was not in force in the Teesdale rural or Auckland rural district, both of which are drained by the Tees above the intake. All medical men are aware that there are slight cases of enteric fever which easily escape recognition, and, indeed, some so slight as to be scarcely recognisable. It is not an uncommon experience, even in well-marked water epidemics, to find no clear trace of enteric fever among the persons who have contributed excreta to the sewage polluting the water supply. But, apart from this, the medical profession at all events has come to recognise the possibility of the poison of enteric fever living outside the human body, and even the impossible demonstration of entire absence of enteric cases from a given area could not, in the present state of knowledge, completely establish Mr. Wilson's point. This consideration adds to the difficulty of accepting, as a logical necessity, the assumption that nothing could be washed down by one flood which had not been freshly deposited since the previous flood."

There is also that which I shall have to say presently on the matter of the efficiency of one and another kind of filtration; but I would here state that that affected in the case of the Tees water was far from the standard which Professor Koch has found to be an essential for the adequate protection of the community against waterborne disease. Professor R. Koch has laid down a definite rule that no water which is intended for human consumption should be filtered at a rate exceeding 100 mm. (3 95 inches) per hour, and the rate in the case of the filtering beds of the two Water Boards having dealings with the Tees was much faster than that thus allowed by Professor Koch.

There is a further startling statement made by the Royal Commission on Metropolitan Water Supply, namely, that having reference to the amount of polluting material necessary to the infection of a river which is to be considered as capable of disseminating disease to consumers of its water. In the paragraph last quoted they make mention of their inability to admit the hypothesis as to the passage down the Tees of infective material in quantity sufficient to cause such an extensive outbreak, the more especially since the water is subjected to filtration. They also refer to the absence of like experience from other places in support of Dr. Barry's theory of river pollution as a cause of epidemic typhoid. Indeed, they state that if the Caterham outbreak of 1879 (No. 102) be taken as a type of the amount of polluting material requisite to cause an outbreak, then it would call for nearly half a million fever cases in the Thames valley above the intakes for a fortnight before the consumers of the London river service would be exposed to conditions operative for harm in the nature of a typhoid epidemic. This, they say, when the population is only about one million in the entire valley, and the water filtered, is almost impossible. Accordingly, the Commission are content to believe that the metropolis is safe against such an event as has happened in the Tees valley. True, no evidence has been published which incriminates Thames water as delivered to the London water mains of causing typhoid fever. But what I would ask is, Has it been decided how small an amount of infective material in a large volume of river water is requisite to the pollution of that water in such degree that it will still disseminate typhoid in its consumers? If it has not been decided, then what footing have the Commission when they hesitate to accept Dr. Barry's theory of Tees water and typhoid as cause and effect? Sir George Buchanan, in speaking on this matter of the amount of polluting matter necessary to the spread of typhoid, has stated as follows in his annual report for 1881 to the Local Government Board:

"I learn through the Chairman of Directors of the Caterham Waterworks Company that 1,861,000 gallons of water were pumped from the well during the fortnight. If the water had for the whole fortnight contained one grain of excremental matter per gallon, this would have meant that 19 lbs. of excrement had been added to each day's supply of water. It is, of course, out of the question that the man evacuated any such quantity; neither is there any reason to suppose that every gallon received the same amount of contaminating matter; but the story may serve to show that in speaking of one grain in the gallon we speak of a very large amount of polluting matter present in the water. It may be thought of as an amount not likely to have been exceeded in the particular samples of Caterham water that did actually produce disease in the individuals who drank it. In Dr. Cory's experiments, then, with one grain of enteric fever stool per gallon, we see a water thus largely befouled by a most dangerous material; and the indication of that befoulment, when expressed by the chemist in terms of albuminoid ammonia, is the figure 0.014 part per million parts of the water. Wherefore it is not permissible to accept the doctrines which have been formulated from the amount of albuminoid ammonia present in an otherwise unknown water. Polluting material, potent for harm, may be present in a water yielding from 0.00 up to 0 05 parts of albuminoid ammonia per million, without removing it from the rank of waters of extraordinary organic purity; and we assuredly have no evidence, in the case of an unknown water showing from 0.05 to 0.10 parts of albuminoid ammonia per million, that it is safe organically. The lesson is taught afresh and significantly by Dr. Cory's report that while we must ever be on the watch for the indications that chemistry affords of contaminating matters gaining access to our waters, we must (at any rate until other methods of recognition are discovered) go beyond the laboratory for evidence of any drinking water being free from dangerous organic pollution."

I myself strongly incline to the view that an infintesimal amount of the poison of enteric fever in drinking water is sufficient to cause the disease in those consuming the water.

Indeed we know, from eminent bacteriological research, that the bacillus of enteric fever is, when present in water, there only in proportion relatively small; and that the organism even when present in water in the bulk, may be entirely absent from the small quantity submitted for examination. And again, other microbes may be present so numerously in typhoid-polluted water as to render obscure, and even to prevent recognition of, the scantily present bacilli of typhoid fever. This was prominently brought forward in the case of the Worthing outbreak of 1893. (*See* also Appendix A.); and again finds place in the report of the Royal Commission on Metropolitan Water Supply. On the question of the amount of polluting material necessary to induce typhoid as the result of consumption of water, Professor Odling seems to regard "a very considerable dose" as essential; and others appear to hold the same view. But Dr. Sims Woodhead admits that in respect of typhoid, knowledge on this point is not definite. He even says that the entry into a domestic cistern of one single specimen of the bacillus of typhoid might, by reason of multiplication in the cistern, prove a danger to all the household consuming the water.

Coming to an actual occurrence, additional to that of Caterham, where the evacuations of a single typhoid patient may be regarded as in all probability the starting point, indeed, the *vera causa* of an alarming epidemic of the same disease, I would here like to draw special attention to the prevalence of the malady at Blackburn in 1881. The outbreak embraced in all 260 attacks in the period February to May of that year (No. 128), and Dr. Airy, in his careful and elaborate report, sets forth with great clearness the details of the occurrence. I shall have occasion at a later stage to refer at greater length to this instance of waterborne typhoid, but treating of it here from the point of view of great harm following small beginnings, I will leave for the time the general question of water consumption and fever as cause and effect.

Dr. Airy records how, in his opinion, the dejecta from a single case of typhoid at Shorrock's Row, Guide, shown in the plan given at a later stage, gave rise to the epidemic. He puts out at some little length how the drainage of the privy, into which the dejecta were cast, could have found its way into the reservoirs which supplied Blackburn. The case was one of undoubted typhoid, and the evacuations had carbolic acid cast over them by an unskilled labourer, neither the health officer or nuisance inspector proceeding to the spot, despite the fact that the town water service was palpably endangered at the place of occurrence. The attack was certified on February 22nd. A reference to the plan will show the manner in which the public supply was threatened, and when I have occasion to mention this outbreak on a later page, I shall have to point out the extreme liability of the culvert furnishing water to the borough to pollution from the row of houses in which this case was treated. I need not follow Dr. Airy through the successive paragraphs in which he seeks to prove that the Blackburn water was liable to contamination by these specific excreta; let it suffice when I state in his own words that "it appears that in the latter part of February every section of the water supply of Blackburn contained more or less of the water that had passed through the conduit under Shorrock's Row. Therefore, supposing the conduit water at that time to be the vehicle of enteric fever, we can see how a general outbreak of fever in the early part of March in different parts of the town might be accounted for." Now there were three reservoirs to which the drainings of the dejecta could have found their way—namely, Guide, with a capacity of 90,000,000 gallons; Fishmoor Lodge, 310,000,000 gallons; and Audley, 12,000,000 gallons. We are told that the second had only 50,000,000 gallons in it when Dr. Airy was there, so that there could not have been more than a total of 152,000,000 gallons at most when the inquiry was held; but how much less is not told us. Here then is an outbreak undoubtedly due to waterborne infection, and in which detailed inquiry enables only one attack to be looked upon as the origin of the large epidemic among a vast body of people drinking from three different storage reservoirs, whose relationship at a time coinciding with the alleged specific fouling of their waters by that case lends itself to corroborate the strong probability that the outbreak was in fact thus brought about.

We have seen already in milk outbreaks of typhoid how a great many of those using the infected milk escape the disease, not because they are not susceptible to the disease, but on account of the fact that the infective germs of the fever are not uniformly distributed in the milk, households thus in many instances receiving milk free from the dangerous ingredients which are contained in that supplied to, it may be, the very next house to which the milk is taken. May it not well be so with water in reference to the germs of typhoid? Professor Koch has stated that when enteric fever is found to be occurring in largely increasing quantity over an area supplied with the same water and unconnected case with case, it will be well to seek for evidence of water as the cause. In any case, pending the settlement of the vexed question of the direct relation between rivers and typhoid as cause and effect, would it not be best to take the excellent advice offered by the late Sir George Buchanan? I refer to his statement that if populations are so situate that they must needs pollute the river on whose banks they reside, the river should be frankly recognised as unclean.

"Thus," he says, "regarding rivers as sources of drinking water, one of two positions ought, I submit, to be consistently aimed at—either that, being a necessary source of domestic water supply, the river shall be absolutely protected against pollution; or else that, being (in whatever degree) used as a sewer, it shall be classed as not fit to supply drinking water."

For the rest as regards this particular instance of the Tees epidemic, I am content to know that the chief medical adviser of the State on public health matters, Dr. Thorne

Thorne, has (as previously stated) said, in presenting the report which Dr. Barry made upon it, that "seldom, if ever, has a case of the fouling of water intended for human consumption, so gross or so persistently maintained, come within the cognisance of the Medical Department, and seldom, if ever, has the proof of the relation of the use of the water so befouled to wholesale occurrence of enteric fever been more obvious and patent."

Canals as Water Supplies.

In his report on the river Trent, to which I have already had occasion to advert at some length, Dr. Bruce Low gives prominence to the use of canal water in relation to typhoid causation. This is especially the case in respect of the villages of Misterton and Walkeringham, in the Gainsborough rural sanitary district (No. 174). In view of the fact that canal water was still being used here in 1893, I think I ought to show what were some of the constituents of the supply which the villagers were consuming. Accordingly I quote a short passage from Dr. Low's report:

"The Chesterfield Canal, which passes through the parishes of Misterton and Walkeringham, joins the Trent at West Stockwith, where are a lock and canal basin. Inland beyond Misterton, and to the south-west, the most important place on the canal is Retford, whence cargoes of nightsoil are brought in barges for disposal on the celery-growing land in and round about Misterton parish. From the south-east cargoes of nightsoil are also brought into the Chesterfield Canal from Gainsborough, and from Lincoln *viâ* the Foss Dyke, another canal which joins the Trent at Torksey. This nightsoil, along with towns' manure, is unloaded on the banks of the canal in Misterton parish, sometimes close to the village, and some of the filth is usually spilt into the water and on the banks during the process of unloading. The nightsoil before being carted away is heaped up on the bank, a few feet from the water's edge, and eye-witnesses inform me that they have seen the liquid filth exuding from the heap, running directly into the canal. The bilge water remaining in the barges after unloading is pumped out into the canal. The amount of nightsoil manure passing *viâ* the canal from the river Trent is estimated at from 500 to 600 tons in the year; this does not include that which comes from Retford in the other direction."

This surely is bad enough; but even worse is told by Dr. Low, since he says that this canal water has a "general preference" expressed for it by the villagers as opposed to pump wells. In the same report we are told that the town of Thorne derives its supply of drinking water from a canal fed by the waters of the river Don. True, the supply is subjected to some amount of filtration of a rough character; but the canal itself is the recipient of untold abominations. Dr. Low says: "The canal in question is fed by the waters of the river Don, which itself forms, for some miles above, a part of the navigable waterway. The Don is largely polluted by sewage and other refuse matters in its course through the Sheffield, Rotherham, and Mexborough districts, and other populous places; it is also continually contaminated by the bowel discharges, urine, and slop water of a large floating population. On one occasion, a few years ago, the number of canal boats passing up and down through the Thorne Lock in one week was counted, and the number enumerated amounted to 500.......So that 500 boats carrying each four persons would represent 2,000 persons contributing excrement to the canal in the Thorne district at one time or another during the week. Habitual throwing into the canal from barges of all their excrement and slops by boatmen was not denied.......Towards the Doncaster end of it I myself saw many loads of black sludge being taken out. One lock-keeper told me he often saw the carcasses of dead dogs and cats in the canal, and that he had occasionally himself to assist in taking out of the water the decomposing bodies of drowned persons." That canals should be totally prohibited as suppliers of drinking water no one, I take it, will seek to gainsay after reading what is here said.

Filtration of Drinking Water.

The importance of the method of filtration adopted in regard of water intended for human consumption need hardly be asserted. And yet it is one which has received far less attention in the past, at least in our country, than should have been given to it. Professor R. Koch has brought out very clearly in his paper of 1893 on Water Filtration and Cholera that it is not the sand of the filter beds that acts as the purifier of the water passed through the filter, but that a layer of mud on the top of the sand, brought there by a deposit from the still unpurified water, is in reality the means of filtering the water. The most important point in connection with efficient filtration is the deposition of this layer of mud, which after formation should not be disturbed until it becomes so thick that it requires removal on account of its impermeability. The layer of sand below this deposit should never be permitted to get under a certain thickness, about 30 cm., and in respect of the filtering mud layer it is essential that the water to be passed should in the first instance be allowed to remain on the sand bed a sufficient time to deposit the mud, the time required to bring about the deposit differing with different waters and the capability to rid themselves of their suspended mineral and vegetable matter. Some river waters, we are told, which are especially rich in clay constituents can deposit a good filtering mud layer in eight or ten hours, whilst others, having vegetable matter in suspension, require at least twenty-four hours for the process; hence the matter of sand filtration is seen to be by no means the simple subject that many have supposed it to be. We are further told that if a filter works satisfactorily there should never be more than 100 germs capable of development in each cubic centimetre of filtered water, and this notwithstanding the number in the unfiltered water, whether 100,000 or only a few hundreds. In the case of very contaminated natural water the germs after filtration should never exceed 100 in a cubic centimetre. A small proportion of the bacteria found in filtered waters have their origin, according to Fraenkel and Piefke, in the natural water; hence the very best filters yet devised cannot rid the waters of all micro-organisms, with the sole exception of the Pasteur filters. Indeed, at the rate of filtration which Professor Koch would allow, he fears that the bacteria of cholera could not be kept back; but whilst sand filtration cannot be held to give absolute protection against danger of infection, "it can give such a protection that in practice we may, under existing circumstances, be satisfied with it." The danger to be feared from the process of cleansing the filter beds is adverted to, and it is shown that even with the most careful manipulation of the plant there will be some disturbance of the filtering area by the inflowing water after the beds have been cleaned. This, however, need be but slight, and danger may be avoided if the proper precaution be taken of permitting the water to rest for the hours requisite to allow of a deposit before the filters are again put into play. Commenting on the cholera outbreak at Nietleben in 1893, Professor Koch states that if proper bacteriological examination had been made of the so-called filtered water prior to the outbreak, such an examination would have sufficed to show that the water passed through the filter beds was not of such a quality as was proper to be sent into the service reservoirs. The object to be aimed at in that case seemed to be to get as much water as possible through the filters, irrespective of the nature of the filtration to which the process treated the water. The fact was not appreciated that the water needed to be allowed to rest for four-and-twenty hours on the sand previous to fresh use of the filter beds. To such ignorance Professor Koch would seem to refer the cholera epidemic outburst at the asylum there.

This brings me to the further and very important matter of the periodical and frequent examination of water, after filtration, in a bacteriological sense.* It is perhaps scarcely necessary to state that in England this question has not received the amount of attention which it merits. Unless I am greatly mistaken, the waters of the individual companies supplying London are only examined (to the extent of a few drops) once a month. But what do we find Professor Koch saying on the matter? This, namely, that there should be a rule that each filtering basin should when in use be bacteriologically investigated once every day, the basin being so arranged that a sample of the water can be taken immediately after passing the filter, and prior to mixing with the waters from other basins or reaching the storage reservoirs. He does, however, go on to say that if waterworks are so constructed that they give uniformly good results, periods of greatest use of water, of frost, or of danger of epidemics, are alone those in which the strict insistence of a daily examination need be carried out, an examination every three days of the total filtered water being in the meantime sufficient. But the practice of a weekly bacteriological examination at any time is recorded as insufficient. I much fear that the water companies of our country, if judged by this standard, would come out of the ordeal very badly. And again, if the water passing had in our country to stand the test of having a number of germs capable of development in each cubic centimetre below 100, I imagine that the companies would be in equally bad case. If we apply these various desiderata to the case of the Tees water as supplied to consumers, I am afraid that the inability of the Water Commission of 1893 to determine whether the fever in the Tees valley was or was not waterborne is shown to have less justification than ever. Coming to an instance of filtered water which has seemed certainly to have caused typhoid, I would draw attention to the case of the Chester-le-Street outbreaks of the winter and spring, 1892-93 (No. 195), where the incidence of the disease was most emphatically marked on one of two water services in the place. The data given in the appendix sufficiently demonstrate this fact. The inquiry which was made of the prevalences of typhoid for the Local Government Board by Dr. Maclean Wilson is an admirable instance of the reports issued by the Medical Department of that Board, and I feel that I may with advantage to this paper quote from the document as to the methods of filtration found to be in vogue when Dr. Wilson visited the district. The length of the extract is only the measure of the importance of the subject dealt with.

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* In this connection I have thought it well to print in appendix the account which Dr. Klein has given of his "methods of examination" of water when searching for the bacillus of typhoid.

"The Chester-le-Street Company draws its supply from the Stanley Burn, about two miles above the village. At the intake there is a weir to direct the water into the pipes, the open ends of the pipes being protected by a double wire screen to keep out leaves and other floating bodies. But at the time of my visit these screens were so arranged that the water did not require to pass through them to enter the pipes. A few yards lower down these intake pipes deliver into a settling tank about 3 feet square, and from this the water flows into the main, which is said to be covered by a rose. The main conveys the water by gravitation (with a fall of 130 feet) to a filter bed. The man in charge says that there are several valves in the course of the main through which the water can be turned into the stream again, and that these have to be opened occasionally to scour the pipes, in order to keep them clear of sand and mud. The filter bed, which is situated on some high ground close to the village, and within 200 yards of the railway station, seems to have been made when the company was first formed, and not to have been much disturbed since, except for renewal of sand in a way presently to be described; at any rate, I am told that it has not been opened out for the last thirteen years. It is constructed of brick and mortar, forming a tank 24½ feet by 49½ feet, and of unknown depth. Surrounding it on three sides in the form of a horseshoe is the service reservoir, covered in, and, I am told, constructed of brickwork with a coating of cement. It is said that the filtered water enters this reservoir through holes in the walls of the filter bed. The filtering medium is said to consist of 4 or 5 feet of gravel and fine sand, with a layer of cobblestones at the bottom of the tank, but, as will be seen, the thickness of the sand varies immensely at different times. This is the method followed: Once a year, after the clogged surface layer of sand has been removed, about 150 cartloads of fresh sand are poured in. This sand is procured from the banks of the Wear close by, having been deposited by floods, and the Wear above this point receives the untreated sewage of a large population, both urban and rural. The water is turned on to the filter bed, and allowed to run through it until the surface layer of sand begins to get clogged, a period which varies from ten days to three weeks, according to the state of the water. The water is then turned off, and the bed allowed to dry, when the man in charge skims off about an inch of mud and sand, and delves the new surface to a depth of a foot or so. The water is again turned on, and the same process is repeated throughout the year until the sand has been in the main removed, when another 150 cartloads have to be filled in. The process of paring the surface of the filter was done in my presence, and I was told that the level of the sand was then at its lowest, as it was time for its periodic renewal. At that time the surface of the filter was 5 feet 5 inches below the level of the overflow pipe, and I was told that 3½ feet of additional sand was to be thrown in, so that the thickness of filtering medium varies as much as 3½ feet. As has been noted above, the filter bed is surrounded on three sides by the reservoir; on the fourth side is well-manured garden ground, extending up to the wall of the filter bed, and as the wall is made apparently of ordinary brick and mortar, and is dilapidated in many places, there is no doubt that in time of heavy rainfall the soakage from this garden gets into the filter bed. The reservoir is said to contain sufficient water to last for a fortnight if the supply is turned off at night. On the town side of the reservoir is the valve pit containing the pipe from the stream to the filter bed, as well as the distribution main from the reservoir to the town, and these two are joined together by another short main, so that the water from the burn can be turned into the town without passing through the filter bed. This, however, is said never to be done."

The state of things here set forth is sufficiently deplorable, and if I add that the bowel discharges of typhoid patients were prior to the outbreaks chronicled finding their way into the stream above the intake, there can be little wonder at the resulting dissemination of disease by the water of that stream when allowed, with such poor attempt at purification, to enter the distributing mains. Deplorable as was this state of things at Chester-le-Street, a larger question is behind it—namely, How far does the case represent the condition of water services in our country? The question is of serious import to the community, affecting as it does the public health in no mean degree. If filtration in its most perfect features does not arrest all the bacteria with which water is infested in its natural, and ofttimes polluted, condition, what can be said of water which is subjected to only an elementary process of filtration? If it be contended that water from whatever source will not convey the means of harm when properly filtered, I for one will not quarrel with people who rely on that filtration, if only it be assured that the method of purification is indeed perfect so far as all reasonableness can demand, and such as shall reduce the germs in the water to less than 100 in each cubic centimetre, so far as development is concerned. If filtration is to be our safeguard, let it be of a kind to prevent all cause for cavil by those who look askance at the theory of the safety to be found in it. I must add one qualification to my adherence to the trust to be placed in efficient filtration, and that is my opinion that the water to be filtered shall be a water free so far as can be determined from even the risk of pollution. I refer, of course, more particularly to risk of excremental pollution. What I would like to see undertaken is a comprehensive survey of the several local and other water supplies in use in our country, all our gathering grounds, filter beds, methods of distribution and the like finding place in the scope of such an inquiry. The matter would doubtless take much time, but that would be a small matter if power were given to the department of State carrying out the inquiry to order the remedying of all defects of moment that were found to be existing. If we have regard to the valuable series of reports now available in the cases in which the Medical Department at Whitehall have made local inquiry into the sanitary circumstances of districts in England and Wales, we shall find that very seldom is the water service such as to prove satisfactory to that Department. But dissatisfaction without the power of remedy is but poor comfort to those desirous of righting the wrong.

Before I leave for the time this interesting subject of river water and filtration in relation to typhoid I should like to refer to one other instance of riverborne typhoid, that, namely, of the river Wear, which furnishes the water supply of Bishop Auckland. The data which I give in the appendix (No. 194) will show in a way not to be gainsaid that the incidence was on the houses of consumers of the public supply from the river, even down to four cases in the village of South Church, in four houses taking the same river supply, to the exclusion of all other houses in that village and all houses in surrounding villages using other water. The waters of the river are undoubtedly grossly polluted above the intake of the supply. The Wear receives the sewage of all the towns in the upper portions of the valley, and, in addition, the raw sewage of several thousand people within a few miles of the intake, not including that of some thirty houses in the town of Bishop Auckland itself. But the water is filtered through a natural sand and gravel bank, the chemical analysis of the filtered water showing it to be of much greater purity than that of the river in its natural state. Yet the water is frequently, when supplied to the mains, quite turbid, thus giving evidence of the inefficiency of the method of filtration adopted. In his report for the quarter ended June 30th, 1893, Dr Eustace Hill, the health officer for the county of Durham, states that the "county analyst reported of a sample of water taken from the mill race just below the entry of sewage from houses at West Mill and Daisy Bank, and Latherbrush, 'that this sample yields very faint indications of the presence of actual sewage pollution.'" He proceeds to state very truly that the chemical purity of a water is no indication that it can be consumed without danger, and that at Bishop Auckland the filtration is not always effective; whilst there is evidence of the entry into the river just above the intake of sewage containing the specific contagium of enteric fever, at a time coincident with the outbreak of typhoid which I have chronicled in the appendix. It seems that the methods here adopted would not bear the scrutiny which Professor Koch would bring to bear upon them, and that if cholera were ever to find a footing in the upper reaches of the Wear whilst the conditions obtaining in 1893 are allowed to persist in the matter of a water supply drawn from that river, the chances are that Bishop Auckland will suffer very heavily. This instance, to my mind, sets forth very clearly the folly of trusting to so-called filtration, done in a manner which science has now shown to be short of the requisite. Filtration can only be relied upon when it fulfils the conditions laid down by Professor R. Koch, namely, when it secures a water with less than 100 germs capable of development in each cubic centimetre of filtered water, and where the other requisites of bacteriological examination and the like can be fulfilled.

WATERBORNE TYPHOID FEVER OF ACCIDENTS.

It is conceivable that with our complicated machinery for the supplying of large populations with drinking water there would occur from time to time accidents of a nature to be deplored on account of their far reaching results of a harmful character; and so it is, for the history of waterborne typhoid is not without cases where the outbreaks have been directly the result of accident. I may recall attention to the Lewes epidemic of 1874 (No. 71), brought about by the leaving open of the valve of the intake pipe by some children. To this case I have already made reference in other connection, and so I pass on to consideration of additional instances where accidents have been concerned in the cause of outbreaks. One of the most curious of its kind was the outbreak at Perth in 1880 (No. 112), which lasted from May to November, causing 162 attacks and 21 deaths. It happened in this wise. The sewage of the city was disposed of in the river Tay, and quite close to the place of outfall into the river the mains of the public water supply cross from the filtering beds to the city. On a particular day some repairs were needed to the pipes, and by some error the sewage-polluted waters of the river were allowed to find entry to the distributing mains already charged with filtered water. On the next day succeeding there began an epidemic of diarrhœa in the city, and this was followed at the expiration of a week by an outbreak of typhoid, a circumstance by no means unusual in the case of waterborne typhoid as witness, for example, the instance at King's Lynn. When we state that record of this remarkable case comes from the pen of Dr. Simpson, now health officer of Calcutta, it will be allowed that it demands credence. Of the Bangor epidemic of 1882 (No. 141) much was heard at the time, and after the issue of the report made to the Local Government Board by Dr. Barry. No fewer than 548 cases and 42 deaths occurred, and some attempt was made to exclude water as the cause of the disaster. This entirely failed, however, to convince any unbiassed mind as to the truth of the report, which unhesitatingly put the fever down to the water service. The town was no doubt deserving of a certain amount of commiseration for the lamentable circumstances. There were those who lost their lives by their persistent disregard of the theory of a waterborne pestilence; and yet after all the malady was brought about by an accidental act, if one may call a flood a matter of accident.

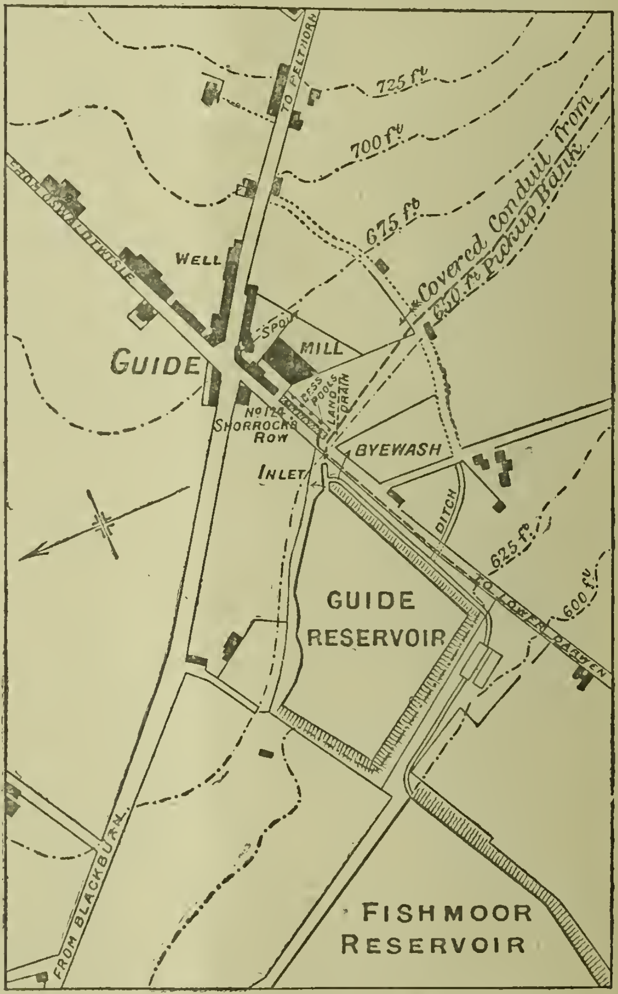
The facts leave no doubt that the river from which the water supply of the place was obtained was polluted some 700 yards above the intake by the excreta of typhoid patients cast into a creek which carried them by means of a rubble drain to the river. The flood which occurred in early July had for its result the bursting of a main, with consequent disturbance of reservoir and filter bed; and this disturbance was followed by a widespread and simultaneous epidemicity of the disease, the fever blazing forth after the lapse of a fortnight following on the bursting of the main. The water was much discoloured after the accident, and smelt badly. Houses not taking it were altogether exempt from fever. To add to the discomfort of those who had much to say by way of doubt of the theory of water, it was pointed out that the filtering beds were inefficient and dirty. And then, again, it can hardly be expected that a river can be polluted by the specific germs of typhoid without grave danger of mischief resulting, especially where the method of filtration is in any wise faulty. Therefore, whilst we may class the instance in our chapter of accidents, it nevertheless remains also as a case deserving of much censure that there should have been permitted to remain such a source of danger to the public water service as the disposal of excrement from houses so situate as to render the pollution of the service possible. If it be held that accidents as such cannot be guarded against, I must enter the lists and give it as my opinion that the health of a community should not be at the mercy of a child, or of an ignorant householder who is content to get rid of his domestic filth without regard for decency or safety. The instance of Perth is probably unique, but it is painful to think of the consequences of any damage or leak occurring in connection with riverborne water pipes, in the same way as it is dangerous to have pipes for water and sewage laid side by side without the greatest of care that any possible exchange of contents is guarded against.

GATHERING GROUNDS AND WATER POLLUTION.

Where drinking water is derived from the surface drainings, the importance of having a gathering ground free from all possible means of pollution is self-evident. And yet to read the history of waterborne disease, one would imagine that to secure a gathering ground that should not directly contribute to the contamination of the supply was a matter of but little concern for those charged with the safeguarding of the public health. I have already had occasion to make some reference to this subject under one or more of the preceding subheadings, but not directly as matter of gathering ground so much as of pollution of streams and the like by surface drainage. This question of the relation of typhoid to the surface pollutions to which water is subjected while in process of collection is one that demands some consideration. We have recently seen some large corporate bodies brought to book on account of the disgraceful conditions which have been permitted to exist along the route of water collection, and to these I shall have to refer in this connection. It will be well that I should make special reference as matter of first instance to a few cases of polluted gathering grounds so far as the facts appear in the appended tables. I will take half-a-dozen instances. The first is by no means the least interesting. I refer to the Blackburn outbreak of 1881, investigated by Dr. Hubert Airy (No. 128), with its 260 attacks. The case is indeed of such vast importance as showing the conditions prevailing when Dr. Airy visited the borough, that I am sure I shall be pardoned if I quote even somewhat lengthily from his report, only premising that the state of things to be now described in nowise obtains to-day. I cannot do better than reproduce Dr. Airy's account of the risks to which the old waterworks supply was exposed by reason of the circumstances in which the water was gathered.

"Now it is evident that this water supply of Blackburn runs the risk of pollution at its several sources. There is risk at the gathering ground above Pickup Bank; there is risk at the White Birk Colliery of some accident similar to that which befell the Caterham well; and there is risk at the well on Revidge, for houses are pretty numerous round about, and the soil is a porous sandstone rock. Moreover, as regards the water from Pickup Bank, there is risk at very many points along the route by which it is conveyed to the town. The stone culvert......is of rough construction, built of the ragstone of the district in rude wedge-shaped lumps, fitted together without mortar or cement, but well bedded in thick puddle; and remembering that this culvert has lain for more than thirty years, only three or four feet deep, on the slope of the hill side, with a constant tendency to increase of pressure on the upper side and lessening of pressure on the lower side, it can hardly be supposed that the structure is still sound throughout. Indeed, on one or two occasions at different points the crown of the arch has fallen in, and probably at a hundred points it has yielded more or less, so as to admit a leakage of subsurface water on the upper side. The Corporation have been sensible of the danger involved in this condition of things, and have, some time back, taken pains to prevent the surface water from lodging on the upper side of the mound which overlies the culvert, by cutting trenches and laying drain pipes to carry it away either under or over the culvert. An inspection made last autumn (1880) by the health officer (Dr. Stephenson) and the inspector of nuisances (Mr. Prebble) revealed the presenee of dangerous nuisances in the shape of town manure on the pastures immediately above the line of the culvert. Freedom of manuring was expressly reserved to the neighbouring owners, tenants, or occupiers by the Waterworks Act of 1845. The only remedy the Corporation can use is to refuse to sell manure to the farmers on these lands. They cannot prohibit the manuring of the land, and the farmers can get manure elsewhere; danger from manuring, therefore, still remains. There is also the sewage and ordure of Belthorn, the village on the crest of the hill above the line of the culvert, to be taken into account. At the time of construction of the waterworks Belthorn had no sewer nor cesspool, but disposed of its slops and excreta close around the dwellings. Of late years the house slops have been received in a roadside sewer, delivering into a watercourse which formerly was impounded in a little 'lodge' close above the culvert, and used to supplement the supply from Pickup Bank. Even to the time of my visit the conduit remained open at this point, but the lodge had long before been emptied by a pipe carried under the culvert. Still it has occasionally happened that this pipe has been choked with rubbish or with snow, and the water has half filled the lodge before it has been possible to clear the pipe again. The water bailiffs, however, declare that the water in the lodge under these circumstances never reached the open conduit. Again, there are one or two other points where sewage from Belthorn has to pass over or under the culvert, and where the accident of a defective joint might admit impure water to the latter. The drainage from one row of houses goes into a cesspool on the hill slope. The cesspool sometimes overflows, and the liquid runs down a lane and enters a drain which passes under the culvert. Even in the last twenty yards of its course, before it discharges into the Guide reservoir, the culvert is in manifest danger of receiving soakage from the neighbourhood of a row of cottages (Shorrock's Row) in the village of Guide (see plan annexed). The slops from these cottages are thrown out partly in front into the road gutter, which carries them over the culvert with no security against percolation except the bed of puddle in which the culvert is wrapped, and partly into a 6-inch pipe drain at the back, which, at the lower end of the row, is carried under the last house and across the road to join a larger stone drain from a higher part of the village."

The above is sufficient to show that the gathering ground was by no means free from sources capable of seriously polluting the water collected in the reservoirs; and Dr. Airy goes on to describe the manner in which he thinks actual pollution may have been brought about by way of the drainage from some privy pits within nine yards of the culvert at one part of its course. Percolation of the contents of these privy pits was demonstrated at the point where those contents passed over the stone culvert, and a case of unequivocal typhoid occurred in February in one of the houses using one of the pits. Moreover, the discharges of the patient were cast into the privy, and though the use of carbolic acid powder is said to have been made, in so far as the stools were concerned, at any rate no such attempt at disinfection was made in the case of the slops and rinsings of vessels. All alike could find their way to the culvert. And even so, Sir Charles Cameron has stated that he has succeeded in developing typhoid bacilli in large numbers from dejecta treated with carbolic acid.* In the next month (March) the disease suddenly blazed out in Blackburn, with 149 cases, followed by 61 in April. Dr. Airy shows that the distribution of the water, complicated as it was, fitted in with the theory of contamination by the excreta of the single case of typhoid just referred to, whilst the widespread and slight incidence on the large population served equally fitted the theory, since, if the one case of disease contributed all the polluting agent then the amount would be very small in relation to the immense body of water to be infected. The heaviest incidence was on that part of the borough served by the reservoir chiefly concerned in the pollution to be derived from the specific evacuations. The case against the water to my mind admits of little room for doubt, and the lessons to be learned from the facts so admirably detailed by Dr. Airy are the folly of collecting water from a gathering ground subject to manurial and other means of probable pollution of the water so collected, and the necessity of looking after any disease within the area of drainage of water, rather than



Plan of a Part of the Blackburn Waterworks, 1881.

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* British Medical Journal, August 11th, 1894.

leaving the matter to the chance operations of an unskilled labourer, as was done in the case of the initial attack, which very probably was the starting point of the deplorable epidemic which lasted from March till May of 1881. Another instance of most foul conditions obtaining around the water used by a community subsequently invaded by typhoid was that of Barnoldswick, in Yorkshire, in the spring of 1883 (No. 146), where 48 cases occurred. The well here in question was, we are told by Dr. Atkinson, the health officer, fed from ground saturated by sewage, and itself situate between two sets of cesspools which intercommunicated, fever presenting in some of the very houses draining to the cesspools. Small as were the proportions when compared with the epidemic just chronicled, I much doubt if a case more deserving of censure of the sanitary authority can well be imagined. The people were for all the world drinking their own excrement, and veritably consuming the poison of typhoid. At Cowpen, where enteric seems to be almost endemic, there was an epidemic consisting of 74 cases and 13 deaths in the spring of 1884 (No. 151). Here the water was derived from a stream which received the drainage of highly manured fields on which human ordure was deposited for manurial purposes, and the heavy rains of the winter months preceded the outburst. In the case now to be referred to, three farmsteads were situate on the area from which the water was collected. I mean that of Swansea in 1885 (No. 161), where nearly 600 attacks were recorded, and nearly 50 deaths were registered, in two months of the summer. At two of the three farmsteads there occurred, it is supposed, cases of typhoid, and the evacuations of the patients under the local conditions and methods of treatment could not fail to gain access to the reservoir through the medium of the watercourses proceeding from the houses. The fever outbreak was conterminous with the service of water from the particular reservoir subjected thus to specific contamination, those districts outside this supply totally escaping. It is but right to state that immediately information was received by the sanitary officials of the suspected cases at the farms, and the danger to be appended therefrom, the water from the implicated reservoir was cut off.

As testifying to the fact that it was to the consumption of this water that the fever was due, it was found that at the time at which the action of cutting off the water might be looked to, to bring about a decline in the number of new cases, such declination did, as a matter of fact, take place. But the lesson here is again plainly written, namely, the folly of having within the area of the water drainage system any dwellings from which danger may be apprehended in the not unlikely event of specific disease manifesting itself on the premises, where, indeed, the methods of excrement disposal are such as cannot be regarded as absolutely to be relied upon as without the possibility of accident to the water service. Farmsteadings, with their invariable dirt and litter, are the least desirable dwellings to have near a gathering ground, at any rate, as we know such places in general. The instance of the outbreak so recently as 1891 at Rotherham, Rawmarsh, and Greasbrough, will still be fresh in the minds of many people, and its lessons are sufficiently important to warrant me in bringing the chief facts to the remembrance of any who may be without intimate knowledge of them at the present moment. The two former towns, and a definite but small part of the last, had a water service in common, furnished by the Rotherham Corporation. This service was from two gathering grounds and two wells. These gathering grounds (see No. 190) were subject to all manner of polluting media, especially one, the water from which had great bulk (87 per cent.) of the total cases occurring, and these numbered in all 251, with 35 deaths, from October to December. The water supply was the only community of condition in the invaded areas. Now, the pollutions to which the gathering grounds were exposed comprised such dangerous elements as the drainage of highly-manured fields, on which were deposited the refuse of farmyards and the contents of privy middens; and in addition the sewage of whole villages found its way into the water; and, to crown all, the filtering beds had none of them been cleansed since 1885, one, indeed, not since 1881, analysis of the water for a series of years being of a compromising nature. That there should have been found in England such a combination of deplorable conditions obtaining in connection with the water service of one of our towns as has been the case at Rotherham is a sure sign that our boasting of our immense progress in matters sanitary is rather premature With different climatic conditions in our country, who would like to predict what would happen in a time of adjacent cholera?

To close this sickening array of facts as to the manner in which potable water is drawn from the surface of sewage-laden land, I take note of the case of Atherstone (No. 199), where the outbreak of 1893 was related to the pollution of the water by way of a piece of common land thickly covered with animal ordure; a large pond also contributing its mud and filth to the pollution, whilst the collecting tank had in its near vicinity a place of defæcation for numerous tramps. I have referred somewhat fully to this outbreak already, in connection with the question of levels of mains as affecting the distribution of typhoid, and so I need not here recapitulate. But that a piece of ordinary common land should have been allowed to furnish water by drainage for a town seems scarcely credible. Nevertheless, the fact remains that Atherstone was content to see its water collected in the way described, with the results that will always follow on such a state of affairs. The whole subject of the relation of gathering grounds to typhoid enters so largely into the history of those outbreaks which have been traced to water as a cause, that I have felt no hesitation in thus lengthily speaking of the matter; and it seems to me that it is one that needs much more consideration than has hitherto been paid to it, since we see that some of the most glaring instances on record are of quite recent date. The entire question of surface drainage in so far as drinking water is concerned, calls for remedial action on the part of our companies. Far better trust to polluted waterways, such as rapid rivers, than to the constant presence of infiltrating human ordure, or the rank sewage of villages where disease may at any time become epidemic. Indeed, with efficient filtration, I would much rather see my drinking water coming from a polluted river than from the surface of meadows heavily manured by the visible refuse heaps collected from privies and the like. For one thing, the chances of a river ridding its waters of the harmful qualities of the polluting media are much greater than in the case of water gathered from saturated ground full of abominations, close to the tanks and reservoirs or to the streams which feed the service pipes and places of storage. Of two evils I would choose the least likely to cause mischief.

Churchyard Drainage in Relation to Typhoid Fever.

Man, however, does not appear content to pollute his drinking water by the voided filth of the living, but is too often careless in the matter of contaminating his supply by the drainage from the resting places of the dead, and thus it comes about that danger arises from the proximity of burial grounds to the areas of catchment for water impounding purposes. I will briefly refer to two instances in which the proximity of churchyards to sources of drinking water was seriously held in question. The two cases are wide apart in point of time and locality, the one being at Malpas, in Cheshire, in 1871 (No. 27), and the other at King's Lynn in 1891 (No. 189). At Malpas the churchyard has been in use for for many centuries, and not only was it situate on porous soil, but it was so located that all the decomposing animal matter getting away was led to the source from which the water supply was obtained. In the case of King's Lynn, the drainage of a churchyard into the Gaywood river, which furnishes the public water supply, was only one of very numerous sources from which the river derived pollution. Still these two instances serve to indicate the fact that places of burial are at times so placed in relation to water services that their natural drainage finds its way to the water drunk by man; and it does not want much thought to come to the conclusion that their proximity to sources of supply is, to say the least, very undesirable.

Exceptional Sources of Water Pollution.

One very peculiar case of pollution of water is reported by Dr. Beveridge, of Aberdeen, as having occurred at a dairy farm there in 1881 (No. 129). The cistern at the farm was situate in a corner of the cowshed, its contents being used for all dairy and byre purposes. Analysis showed the water to be pure prior to entry into the cistern, but to become highly polluted with organic material while in the cistern. All the 322 cases of fever occurring in the month of April were in consumers of the milk from this dairy, and no condition of the milch cows could be discovered, after very careful examination, to account for infectivity of the milk by the cattle. No one taking other milk was attacked, and persons whose cans were not washed in the cistern water escaped the fever. The epidemic was sudden, but as widespread as the distribution of the implicated milk. During the progress of the prevalence Professor Cossar Ewart discovered in the milk organisms identical with those found in the cistern water. The case is interesting as showing that despite the patent fact that the water was the *vera causa* of the epidemic, there is no knowing in what manner the water obtained its infective quality.

Chance Sources of Water Supply and Typhoid Fever Outbreaks.

In a category not far removed from the chapter of accidents to which I have lately referred, come those cases in which chance sources of supply of drinking water have figured as cause of typhoid fever. Two such instances of use of water in a more or less accidental way I may quote in this connection. They occurred widely apart in point of time and position, namely, the one at Bristol (No. 79), and the other at Evesham and neighbourhood (No. 142); the first in 1875 and the latter in 1882. In the first, it was among the inmates of an institution that the fever spread, the immediate cause of the 500 attacks which developed being the chance drinking by some of the orphan children of the contents of a stream during one of their walks. The stream received the sewage from houses in some of which typhoid had occurred, and as a result of this consumption thirty cases cropped up simultaneously in the asylum in children having thus drunk of the specifically contaminated water. The disease once introduced, was kept going until 500 children had caught the infection out of some 2,000 in the asylum. Here, then, was quite an accidental usage of a water by thirsty children while out for a walk in a dingle near their home. And it has its lesson for other large aggregations of young persons when out of the charge of the attendants usually looking after them. The second instance was of a most exceptional character, having to do with the visitors to a regatta who, in some numbers, drank of the water of a well in a meadow near where the regatta was held, the well being contaminated with animal organic matter, and situate near a sewer. As showing how the disease was caused, I may mention that the infection was found to be present in eleven villages, the early sufferers being all of them users of the well on the day of the regatta, either in its natural state or in the form of lemonade mixed with spirit. Not one case of fever occurred in the large number of persons who thronged the other frequented meadow. The water of the well showed on examination signs of undoubted pollution, but the use of its water was a matter of accidental congregation in the meadow in which it found place.

Cause of Fever Distant in Time.

There have been not a few instances in which the cause of the outbreak of waterborne typhoid has been far distant in point of time from the result of its operation. I have already, in speaking of the action of frost and thaw on the spread of such typhoid, had occasion to mention the lapse of lengthy intervals between the disposition of the infective material which has later given rise to disease and the disease which has thus been created. It must indeed often happen that the one and the other will be somewhat widely separated, for the reason that climatic conditions have so much to do with the infiltration of the specific germs of a disease into the water. It will readily be granted that excrement cast on to dungheaps in a period of frost and in a time of heavy rainfall will reach an adjacent watercourse under the latter conditions much more quickly than when the surface of the ground is frostbound. We have again and again seen heavy rain causing typhoid epidemics by the action of the water newly fallen on the ground in its forward course either on the ground surface or with the subsoil water thus augmented, and acquiring a fresh impetus towards its natural level. To the instances under these headings I need not again refer; and with what has already been said on these points it will suffice if I give one instance in which neither frost nor thaw was in question, but where the cause was in existence in the spring of the year and the result was manifested in the summer. The case of which I am thinking is that of Swansea, which town, but not this outbreak, I had occasion to mention in another connection a short space back (No. 107). Here, as will be seen from the appendix, the outbreak with its 640 attacks was traced to the fouling of feeders of a reservoir by excremental pollution from a farm on the gathering ground of the service, the fever having occurred four months before the epidemic outburst, the immediate agency being a heavy rainfall. Here, then, it is seen that though frost and thaw had no place in the delayed outbreak, yet rain had a prominent part assigned to it; and indeed it may be laid down that the majority of such delayed appearances of effect following on cause are accounted for in one of two ways, namely, either absence of much rain or frostbound specific poisonous material which needs only opportunity for access to drinking water. These considerations point to the need for careful tracing back of the meteorological conditions for some time precedent to the prevalence under investigation.

Methods of Spread of Waterborne Typhoid Fever.

That there should be various methods by which disease tends to disseminate itself is not surprising; but this does not remove from the region of surprise some of the methods by which spread is brought about. In the numerous instances in which typhoid has been set going by the medium of polluted water we have generally seen the disease appearing first in those persons who partook of the implicated water to the entire exclusion of all others for periods of time varying with the attendant circumstances. In some—indeed in very many—the disease has run a long course before any secondary cause has been found operating, whilst in others again the disease has soon ceased to operate through the original agency by such action on the part of sanitary authorities as closure of wells, or stoppage of supply, or the like, and has then fastened on other channels by which to propagate itself, as, for example, the methods of excrement disposal, the non disinfection of bowel discharges or of infective slops, the attention of the nurses on the patients to duties which lend themselves to contact with the public, or with matters which come to be used for the preparation of foods or drinks for human consumption. The appendix is full of these various methods of spread of the disease; but I should like to draw attention to one case in which spread was brought about by what looks on the face of it to have been gross carelessness. At Temple Cloud in Somerset (No. 191), there occurred an epidemic of a very limited kind, seeing that it consisted of only 11 cases; but the circumstances were interesting on account of the family history which is contained in the report which Dr. Deane Sweeting made on the outbreak. He states, for example, that in one house the evacuations passed by three young patients were emptied only in the morning, being retained all night in the room occupied by the sufferers and that in addition to this filthy and dangerous practice the nurse did not wash her hands or clean her nails after attending to the children; and he states also as his opinion that the woman probably thus derived her infection. Moreover, no disinfectants were used at this house. The same condition obtained in other cottages in this outbreak, and the lesson to be learned as to the absolute need of perfect cleanliness is one that should be well taken to heart, not only in connection with typhoid, but in regard of all sick rooms, since, if we argue by analogy, we may expect to find a nurse who is careless about her own personal cleanliness, careless also about her patients; and in the sick room most assuredly cleanliness is next to godliness.

There is another method of spread of waterborne typhoid to which I shall have occasion to refer rather fully presently, and that is by means of foods rendered poisonous by polluted water, the chief of these being milk. If it seems odd to any of my readers that I should have included in the Appendix cases in which milk has played the chief part of spread, I would beg leave to state that I have given only cases in which the milk was primarily infected by means of specifically infected water, used either in the washing of milk utensils or in other fashion about the farms and dairies whence the infected milk was distributed; and I hold that these are as much waterborne outbreaks as are those where water is consumed in its natural state. But for the polluted condition of water used in the preparation of food for man these cases would never have had to be chronicled; and, indeed, their presence is a great stain on the state of sanitation in our country, since I opine to the view that our farmsteads are a standing disgrace to us in only too many instances, seeing that from them we derive one of our most staple articles of diet under conditions which are an invitation to disease in far too many places. Again, there are instances on record in which other drinks have been infected by the addition of polluted water, as witness the case of the Evesham regatta (No. 142), where the well water was not only partaken of in its natural state, but was also used for purposes of making lemonade and for mixing with spirit. I might name other methods of spread outside the mere consumption of the water as such, but the table in Appendix furnishes the means of finding them if any of my readers care to carry the matter further. One point, however, I should like to mention before I pass from this subject, and that is that the occurrence of a large proportion of cases in any given outbreak in persons who have not drunk of the polluted water does not necessarily constitute any weakening of the argument as to the water having been the original cause. There are those who would have us believe that if a given percentage of attacks does not occur in the water drinkers, then that the water was not the means of bringing the disease into existence in the particular instance. Such people forget that there are in every epidemic, almost without exception, secondary causes operating at some stages, and it may indeed be precedent to the use of the polluted water. That this has happened in the past I do not doubt, and that it will happen in the future to an even larger extent I feel quite certain, seeing that compulsory notification will give sanitary authorities an immense pull over their earlier predecessors, who laboured under the disadvantage of ignorance to a large degree of the dimensions of an outbreak, and did not in too many cases know of its presence until it had attained the proportions of a dangerous prevalence. Where the circumstances are favourable to the early detection of the polluting agent, and the water is cut off or the means of its contamination removed, then it is pretty certain that the number of cases will be small in water drinkers as compared with those in non-water drinkers if the epidemic be a large one, and there are other means of spread of the disease at work in the district, as we have too often seen in past outbreaks. Let me name a few such examples:

At Wing in 1863 (No. 1), fever was kept going owing to the prevalence of insanitary conditions altogether apart from the polluted well. A typical case is that of Winterton, in 1867 (No. 7), where the disease was associated with the drinking of polluted water, but where to quote Dr. Thorne Thorne, "Given the existence of typhoid fever in a town, it is hardly possible to conceive conditions more favourable for its spread than these existing at Winterton." Another inquiry held by Dr. Thorne Thorne in which local conditions other than the water were in operation to cause the spread of fever was that of Radford, in Notts, in 1870 (No. 23), where the epidemic having been set going by means of water, was kept up by the means of excremental contamination of air and soil, specific material being cast into the streets or middens near dwellings or stored in ill-ventilated houses. Coming to more recent times, I may refer to the case of Northallerton, in 1892 (No. 193), where the disease can be thought of as having in some measure been kept going by the poisoning of air by the sewage-saturated ground. And lastly, not to tire my readers by unnecessarily numerous references, I would draw attention to the instance of Atherstone, in 1893 (No. 199), where the incidence on the consumers of the polluted water was as high as 87 per cent. during the epidemic period, but where the disease, once fairly established, had the prevailing midden system to aid it in its successful attempts to propagate itself, the system in vogue lending itself to such dissemination as actually occurred.

Widespread Infection of Typhoid Fever.

An instance in which the infection of typhoid was of a very widespread nature was that of the three villages of Aylstone Park, Whetstone, and Narborough, in the Blaby Rural Sanitary District, in 1880 (No. 110). No fewer than eleven groups of attacks occurred in these villages, to the exclusion of a fourth village in the vicinity where the nineteen cases which cropped up were related to specifically infected midden privies and poisoned air. What was still more curious was the fact that the initial case in each group served as the cause of spread by means of the disposition of the evacuations in a way readily to contaminate a well. The cases to the total number among water drinkers of 211 occurred in the immediate vicinity of the several wells thus subjected to pollution. Users of other wells were entirely excluded from infection except in the case of the fourth village just mentioned. This instance of widespread results following the disposal of the excreta of only a few cases to my mind raises very decidedly the whole question of excrement storage in our country parishes. The close relation of our drinking water and our midden contents is a matter of the greatest importance, and people seem seldom to realise that filth and disease are synonymous terms until taught the truth by some such bitter experience as at these villages.

Short-lived Typhoid Fever Epidemics.

It will be observed, from the tabulated statement at the end of this report, that there are all sorts of epidemics recorded in regard of period of duration, some being prevalences long drawn out, and others again those of brief operation. Of the latter class I may mention the case of Swansea in 1879 (No. 107), where the cause of the outbreak was itself apparently of short duration, a uniform rise taking place in all the districts affected, namely, in the third week of the epidemic, with equally uniform decline from that time until the end of the fifth week. Yet another case of a brief but sharp prevalence was that of Pentrase, in Cornwall, in 1873 (No. 59), where no less than 28 per cent. of the consumers of the water causing the fever (71 cases in a population of 358, of whom 258 used the well) were attacked in the month of August. At Tregoney, in the same locality, there occurred over 50 cases in December, 1873 (No. 64), in a population of under 800, and some of these derived their infection from secondary causes. The case of the Orphan Asylum at Bristol, already mentioned in connection with chance sources of water supply (No. 79) was one where the primary cause was quickly arrested, and where the disease should have also been at once checked, but where, despite the continued spread of the fever in the institution, the epidemic of 500 attacks was over in a couple of months. Hitchin furnishes another example of short epidemics (No. 144), for there were two outbreaks in the two months of December and January, 1882-83, each of some amount, totalling to 100 cases in all. On the other hand we have in the accidental prevalence at Perth (No. 112), in 1880, an epidemic lasting from May to November, although the primary cause was only of one day's duration. I might quote additional instances, but those here set out suffice to make my point clear.

Waterborne Typhoid Fever and "Abstainers."

In epidemics of waterborne typhoid it is only natural to think of total abstainers from the use of alcoholic liquors as suffering in proportions exceeding persons who make but little use of water in an unboiled state. Of course there will always be a large and major portion of the general community who, while consuming water in part in its natural condition, make use of it also in a boiled form in their daily beverages, in addition to those who also partake of other drinks to the exclusion of water in great measure. But in not a few instances the excessive incidence of attack on abstainers has shown beyond doubt that the drinking water has been at fault. Let me illustrate my point. At Bramham College, near Tadcaster, there occurred a prevalence of typhoid in March, 1869 (No. 12), 19 cases resulting as a consequence of the pollution of the water supply of the establishment by way of a defective closet pipe. Nearly all the attacks were in total abstainers, who were the chief, if not the only, abstainers in the college of 60 or 70 persons. In the succeeding month of the same year, at Ackworth Moor Top, in Yorkshire, there was an epidemic (No. 13) arising apparently from infiltration into the well of the village of excreta from the initial case. I have not been able to find out the exact number of cases, but an

Institution was involved in the outbreak, one that was carried on upon teetotal principles. Both in this institution and outside total abstainers were the first attacked and also the most numerously. These are but two instances culled from many that figure in the annals of waterborne typhoid; and the matter is not astonishing, but calls for the remark that what is needed in these, and other persons also for the matter of that, is that all drinking water should be boiled.

Effects on Typhoid Fever Outbreaks of Boiling Polluted Water.

Following on what I have just said, it will be interesting to consider the evidence which is available as to the influence on typhoid prevalences of the boiling of drinking water, if such evidence be forthcoming. Such evidence is, as a matter of fact, not difficult to find, and I will therefore adduce some of it in support of the practice. As long ago as 1864 the benefits of boiling water were pointed out by the late Dr. E. Seaton in his report on an outbreak at Page Green, Tottenham (No. 4), where in a row of five houses dependent upon local wells all the houses were invaded with one exception, where, namely, the inmates "first boiled all the water which they used for drinking." At Buckingham in 1888 (No. 168) the decline of the disease, which had been waterborne, was attributed in part to the precaution of boiling the implicated water, as reference to the report of Dr. Franklin Parsons shows. Perhaps the most unique instance of the boiling of drinking water in the face of disease is that recorded by the late Dr. David Page in connection with an outbreak of typhoid, undoubtedly waterborne, at New Herrington, in county Durham, in 1889 (No. 176). With a view of guarding against further distribution of the disease by means of the polluted supply, the water of another service was turned into the mains; but this not sufficing in point of quantity, Dr. Page said that "arrangements were made and actually carried out for boiling the supply pumped from the Herrington well before it entered the reservoir.........On the occasion of my final visit.........I witnessed the remarkable and unique instance of delivery to the mains of a water supply which had been actually submitted to a boiling temperature." Again, Dr. Bruce Low points to the fact that in the village of Nunnington, in the valley of the Rye, the fever ceased to attack the residents a fortnight after the issue of a warning to boil all drinking water. In reporting on the use of the Trent water for domestic purposes in relation to the incidence of typhoid on riverside populations (No. 174), Dr. Bruce Low states with reference to certain villages having but little typhoid, that their escape may be thought of as having to do with the use in them for drinking purposes of boiled water only. Indeed, in the district generally the medical men have done much apparently to stay the spread of typhoid by their counsel as to the boiling of the river water. And though I have made mention of Nunnington only in speaking of the Ryedale fever, Dr. Low thinks of other villages as owing their immunity from the disease to the same practice as obtained in that village. It will be evident from what is here said that the precaution is not by any means overlooked in the actual presence of the disease, but I much fear that the measure is too often neglected among our people, especially in our large towns, where persons seem to fancy that there must be safety, by reason of the water undertaking being in the hands of some body corporate or the like. But if the circumstances relating to the filtration of some of our water services in even the largest towns in England were to be made public, I doubt if we should be as a community so disposed to place blind trust in our water companies. The expedient of boiling the quantity of water needed in an uncooked state each day is a simple one, and the necessary quantity to be so treated can soon be gauged. Prevention is not only better than cure, but in this case at least it is infinitely cheaper.

Sanitary Inactivity and its Results.

Where so much could be said on this subject it is difficult to quote examples. In modern times the glaring instance of Rotherham stands out very clearly (No. 190), and I have already referred to the conditions which have long held in that town in relation to water supply. Dr. Theodore Thomson, in reporting on the cholera experience of 1893 there, said: "Rotherham had in 1891 actual experience of loss of life and health from fever due to specific pollution of the public water supply, but the sanitary authority do not appear to have profited by the lesson." I need not dwell further on this case, save to say that the medical officer of health states in his annual report for 1894 that the much polluted "Wellgate spring" has at length been closed, with beneficent results already apparent. Equally to the point is that of King's Lynn, of which place Dr. Bruce Low said, in reporting on its fever outbreak of 1891 (No. 189): "The dangerous condition of the King's Lynn borough water supply has been, time after time, pointed out by the medical officer of health and by others. The urban sanitary authority has more than once proposed to protect the water by piping it from a spring or springs, but this project has always hitherto been defeated by a section of the ratepayers who, ignorant of the dangers arising from the pollution of potable water by filth, regard the present supply as all that can be desired." Dr. Low adds the following interesting footnote to this sentence:

"Mr. W. Whitaker, F.R.S., of H.M. Geological Survey, in a presidential address to the Norwich Geological Society, delivered as far back as November 6th, 1883, and published in the *Geological Magazine* of January, 1884, drew attention to the Lynn water supply while discussing certain points in connection with drinking water derived from chalk springs piped to certain towns in Norfolk, as follows:

"'The enterprise of Wisbech is thus in strong contrast to the apathy, and one may say the stupidity, of the larger town, in which I have the misfortune to live, its Norfolk rival, Lynn, the corporation of which treat the inhabitants to one of the worst supplies that I know of. These guardians of the public health allow a set of chalk springs, some pure, but others contaminated, to mix together and to flow along an open channel of six miles or so, as the crow flies, receiving on the way the drainage of a fair tract of country, and at the last, close by the borough boundary, some part of the sewage of the village of Gaywood. Notwithstanding that the evil of this course has been pointed out for years, and constant complaints occur, yet our town councillors, in the multitude of whom there is not wisdom, have not yet made up their minds to any decided action, and a question that really admits of no debate is the subject of apparently endless discussion. "Words, not deeds," should be the town motto, at least as far as regards the water supply.'

"Since the above paragraph was written the town council of Lynn adopted a scheme for the supply of good water, but I fear in a half-hearted way; at all events, their scheme has been rejected at a meeting of the ratepayers, and I am therefore compelled to transfer the charges above made from the members of the town council to the body of the townsmen, who seem not to be educated up to pure water pitch! When they have had a serious epidemic perhaps they may acquire more sensible views on this matter." It is matter for congratulation that the health body have since seen the error of their ways.

At Appledore, where an outbreak of typhoid occurred in 1870 (No. 24), the conditions were disgraceful at the time, and such as to lead Dr. Thorne Thorne to state that "had the town been specially designed to favour outbreaks of typhoid fever.........the result could hardly have been more completely attained than has been the case at Appledore." The report teems with instances of sanitary neglect. At Oldbury the same writer shows a deplorable state of affairs to have existed in 1870, when fever prevailed. His own words best describe the place as he found it at the time:

"Wells are in many instances placed within a few feet of one or more privies and open middens, which are little better than reservoirs for liquid and excremental filth. Some parts of the township are without any water supply, and hence the inhabitants have either to travel a distance of sometimes half a mile to neighbouring springs or they buy it as often as they can afford it of persons who regularly bring it round for sale. This deficiency of water is a point of the most cardinal importance; it deprives the poor of the principal means of keeping themselves and their premises clean, and it must be considered as one of the prime predisposing causes of disease. The poor themselves urgently beg for a proper supply; some informed me that they were compelled at times to resort to the canal, which is in reality the main town sewer, in order to wash themselves; and on several premises I found that lumps of ice and masses of snow had been collected, and were being melted down for domestic use. The want of water has also, in a peculiarly offensive manner, been a cause in spreading typhoid fever, for during the past year some of the inhabitants have been compelled to wait until a rainfall before the linen of the patients could be washed; and the amount of unwashed and poisonous linen which has thus accumulated has, I am informed, in some houses caused an almost unbearable stench."

And here, be it remarked, I am only quoting one short passage to indicate the sort of place it was in which fever thus settled. It may be asked why I go so far back in order to get my instances of sanitary inactivity. My reply is that I have made reference to 2 cases of ancient and 2 of modern history. I do not see my way to showing up the deficiencies of sanitary bodies to any great extent lest I should weary my readers by iteration of much that is already contained in the preceding pages under other headings. The inactivity of our so-called health bodies need not be specifically spoken of as such to enable my readers to grasp the fact that nearly all that is here written is the history of neglected opportunities which, having been allowed to pass, have carried in their train the loss of life and the suffering which are here set out. It has been truly said that cholera saves in our country more lives than it destroys, for the reason that people are stirred up into activity in matters sanitary when that disease threatens or fears of its presence prevail, more than by the fevers that are now endemic among us. But since typhoid has ceased to have for us the horrors that are implanted by a disease which is far less fatal in our midst, these recurring outbreaks which are here chronicled continue to claim their victims. If one death by Asiatic cholera occur in a town, there is an immediate outcry on account of the danger that threatens the place, and people are forgetful of the patent fact that the conditions which operate for the spread of cholera are just those which favour the dissemination of typhoid. Not until the public come to see and understand that the truest economy lies in the reasonable expenditure of money on that which goes to remove the causes which lead to the spread of preventable disease, and which bring death and suffering and distress in their wake—not until then will our death-roll show that diminution in its total which is attainable.

Compulsory Notification: its Benefits in Relation to Typhoid Fever.

It is probably not necessary for me to say much on this subject, looking to the strides which have been made elsewhere in the way of settling the question of the utility of compulsory notification. Our country has decided in almost all its districts that such a system is necessary for the due safeguarding of the public health. The Infectious Disease (Notification) Act, 1889, has worked in a marvellously smooth manner, and has been a marked success. It stands to reason that if the early cases of infectious disease occurring in a district are made known to the sanitary officers at once on their arising, the chance of curtailing the spread of the disease is much more probable than if cases are allowed to give rise to others before attention is drawn to them by some such development as a fatal attack. If the system of notification is in force and proper hospital accommodation be behind that system, the district thus provided is in a fair way to check chance cases of infectious disease from growing into widespread epidemics. Let me give two or three references to reports which show the desirability of prompt notification. The one is that made by Dr. Deane Sweeting on the outbreak at Temple Cloud in 1891 92 (No. 191), in which the writer states that, early cases of typhoid not having been notified, the health officer was not enabled to see that proper precautionary measures were taken, and, as a matter of fact, it was in this district that there occurred spread of typhoid, owing to great want of proper regard to cleanliness in the sick rooms, as I have already taken occasion to show. The other report to which I may refer in this connection is that of Dr. Gresswell on the outbreak at Hebden Bridge in 1884 (No. 155), wherein he states as follows: "The importance of prompt notification and ready means of isolation in Hebden Bridge can scarcely be overrated." And he proceeds to refer to the local circumstances which went to favour the spread of the disease in the absence of such prompt knowledge of cases as should have been in possession of the health officer in order to enable equally prompt measures to be adopted. Overcrowded cottages, the working of members of invaded houses in factories and like aggregations of persons, and other circumstances conduced to dissemination of infection, even though enteric fever was in question.

A case very much in point was that of the Gainsborough rural district, wherein Dr. Bruce Low made inquiry as to the use of Trent water in relation to enteric fever (No. 174). He found that compulsory notification was not in force in the district, and this meant for him much trouble in addition to the feeling that when all was done that seemed possible in the circumstances, he could not be at all certain that all cases of fever which had arisen were accounted for in the lists which were prepared for him. It will be well to give his own words:

"Finally I obtained, after the expenditure of much time and trouble, particulars of cases from all the medical men living and practising in the different parts of the rural district. I soon found that my inquiries would have to be limited to the last four and a-half years. The lists had to be prepared in some instances from memory, with this result: Where a practitioner was having groups of cases every year, some of them club patients of whom no record was kept in ledger or day book, the lists of actual cases were admitted incomplete; but where, on the other hand, the medical men met with sporadic cases only, sometimes not more than one in two years, the facts as to each occurrence remained in their memories, and their lists of cases were much more complete. I have considered it right to make this statement, as farther on I shall have to point out an inequality of incidence of enteric fever in certain localities, the inequalities being for the above reason even more pronounced, so it is believed, than is shown by the figures. A consideration of the two sets of figures will show that the sanitary authority were imperfectly informed as to the amount of preventable illness occurring in the district under their care, and that consequently their officials, no matter how active or willing, could not take the necessary steps to check the further spread of the infection. This insufficiency of information might have been obviated more recently had the rural sanitary authority adopted the Infectious Disease (Notification) Act of 1889."

Dr. Low's report is dated 1893, but in another presented to the same Department in September, 1894, on scarlatinal prevalence in Hucknall Torkard, Dr. Thomas Horne has much the same thing to say of the non adoption of compulsory notification there. Proceeding to discuss the data of the epidemic, he says:

"As to the actual number of non-fatal cases occurring in the district definite information is not, in the absence of notification, forthcoming. The medical officer of health says in a special report on the epidemic which he presented to the sanitary authority, 'It is certain that only a small proportion of the cases were brought to my knowledge.' And again, 'owing to the fact that only a small proportion were notified to me, I am unable to give the number of non-fatal cases.'"

But no one will quarrel with my assertion that the adoption of compulsory notification is a safeguard against the spread of infectious disease, if its information be used aright, hospital accommodation especially entering into the organisation by means of which epidemics are to be successfully combated.

Water-infected Milk and Typhoid Fever.

The relationship existing between dairies and milkshops and the like on the one hand, and the prevalence of typhoid on the other hand, is now admitted to be very close. It was not so admitted a quarter of a century back, when, indeed, the relationship was all but ignored. Writing on the whole subject of the influence of milk in spreading zymotic disease in 1881, I stated that the spread of such disease by the agency of milk was then almost a new danger revealed by hygienic science. Ordinary measures of sanitary (domestic) precaution did not seem to avail to secure immunity against the incidence of disease so spread, although the boiling of milk was seen to be a method of rendering that article innocuous. Upwards of twenty years' experience of milk-disseminated diseases has not led to any general observance of this simple safeguard against those epidemics which still from time to time startle the public by claiming victims from all classes of society by reason of neglect of the precaution of seeing that all milk is submitted to a boiling heat. Many a mother has had cause to sorrow over the neglect of her cook in carelessly omitting the injunction given to treat the milk in the way indicated. As a result of such carelessness the lives of only too many innocent children have been sacrificed. and the sorrow thereby caused has not been in any wise softened by the knowledge of the fact that but for the laziness—I might almost say criminal inaction—of some domestic servant the life taken would in all human probability have been saved. Not that I would be thought of as even seeming to throw the blame for milk epidemics on householders on account of the omission of this precaution—by no means. I simply state that things being as they are it is the duty of every housewife to see to it that the family milk service is treated as an infected commodity. That it should be necessary for such action is my chief complaint, since the condition of the milk trade, to my way of thinking, should be such that this act on the part of householders should be unnecessary. It is indeed against the vendors of our milk supply that I inveigh. The state of a vast proportion of the places whence milk is sent to our markets, and the state of only too many of the shops where that milk is retailed, is a disgrace to our nation. One cannot take up a report on any rural district without reading of circumstances attending the sale of milk from farms which are highly provocative of disease; and I am not here referring to times long gone by. On the other hand I have in my mind instances where the conditions attaching to dairy farms have been most grossly insanitary within quite recent years.

But before I go into the matter any further in a general way, it may be advisable for me to refer to some actual instances in which disease has been traced to milk infected with the specific germ of typhoid by the agency of polluted water. I need not weary my readers by numerous references, so I have taken samples to the number of six from the appended tabular statement with the object of showing some of the ways in which milk is subjected to hurtful surroundings.

At Moseley and Balsall Heath, near Birmingham, in the winter of 1872-73 (No. 52), it was found that of 50 households invaded by typhoid as many as 47 were consumers of a certain milk service, and that at the premises of two adjacent milk sellers the conditions were such that there could be little doubt as to the source of infection of the milk distributed. Midway between two dairymen's premises was a house in which a case of typhoid occurred, the dejecta being cast into a pervious privy in such manner that the contents of the wells serving the houses in question could hardly escape contamination. The water of the one well was used by one of the dairymen for purposes of milk dilution, whilst the milkman on the other side made no profession of selling pure milk. The evidence against the milks was more telling even than that adduced by the above data, since no other cause of fever could be found, and use of the milk of other vendors, even in the same street, was attended by no untoward result.

At Crosshill, in Renfrewshire, in the early months of 1875 (No. 77), there occurred an epidemic of 153 cases, and related unmistakably to a particular milk service. The water supply of the farm whence the milk was sent was from a well situate close to a large collection of liquid refuse, and itself supplied from a spring dangerously situate in respect of a ditch, into which ditch, moreover, or on to an adjacent manure heap, the dejecta of some typhoid cases had been cast.

A somewhat curious case of water-polluted milk was that of a village near Leeds, in the summer of 1876 (No. 87), where some children of a household of ten persons were attacked by a lingering illness of a typhoidal nature. The single cow kept for the purpose of the domestic milk supply had during some months been getting thin, at last refusing to graze Her water supply was a stream into which a watercloset drained and which became "mere sewage." The cow was at length sent away, and thereafter not only did no fresh case of illness occur at the farm, but convalescence set in, albeit of a very tardy character. This instance of, so to speak, transmitted typhoid through the milch cow, is one of much interest. The prominent feature of the series of cases was the lingering nature of the illness contemporaneously with the same tedious ill-health of the cow. It and the instance of the outbreak of the Glasgow Hospitals in 1884, already spoken of in discussing the relations of excrement to typhoid, are the only cases of this kind that I have come across in my study of the subject. In the summer of 1888 an outbreak of typhoid occurred in the village of Millbrook, in Cornwall (No. 113), which has become historic by reason of the prominence to which it attained at the time owing to the report made to the Medical Department of the Local Government Board by Dr. Ballard. The case in relation to milk was what may be called one of indirect infection, since there was no direct communication of contaminated water and milk, the circumstances being as follow. Imported fever having led to specific infection of a street sewer, this in its turn led to contamination of a well through the medium of an overflow pipe. This well caused typhoid in some of those drinking of its water, and the patients' dejecta were discharged by way of privies to a drain which had aërial connection with the room of a dairy farm wherein the milk was stored on shelves, the milk in this manner being exposed to the emanations of the specifically infected drain, with extension of the fever as a result in members of the dairyman's family, and an unknown number of his customers. twenty-two of whom were traced as having suffered. In this case the sale of the milk was never stopped, and the disease went on "until," to quote Dr. Ballard, "the whole village has become steeped with the contagium." If it be in any wise contended that this is not a case of water infected milk causing typhoid, at least it cannot be set aside as a typical instance of waterborne disease, and hence finds fitting place in the appendix. I am, however, content to see it here mentioned in the category of milk-typhoid outbreaks, and to regard water as having played an important part in bringing about the infective quality of the implicated milk. I will only give one more reference to the appendix in this relation, but it will be to a case of most gross inattention to the first elements of sanitation, since it deals with an outbreak which was brought about by means of water which should never have been for one moment thought of as usable for any purpose whatever in connection with the preparation of food for the use of man. The occurrence took place at Great Coggleshall in the winter of 1876 (No. 90), Dr. Thorne Thorne being entrusted with report on the matter for the Local Government Board. He found after inquiry that the undisinfected discharges of a typhoid patient had been cast into a drain which found outlet into a brook, the water of which, only a few yards below the drain outlet, was used for dairy purposes. All the cases of typhoid, to the number of 28, arising from consumption of the milk of this one dairy were among persons who had nothing in common save their milk service, and not one case arose outside this milk service, notwithstanding that there were four milk vendors in the town. The details of a story like this fill one with disgust, which is in nowise lessened by the thought that the milk on one's breakfast table may be merely that which it purports to be *plus* an unknown quantity of typhoid excrement. We live in times not one whit nearer the perfection of dairying from a sanitary view point than when this outbreak happened over eighteen years back. Let me give two or three instances of the conditions prevailing at our dairy farms in recent times.

Mr. Harvey, in reporting for the Local Government Board in 1886 on an epidemic of typhoid at Swanage (No. 163), says of the dairy implicated in the spread of the disease there that it, "like all others in Swanage, has been under no sort of regulation or supervision, and in the circumstances of its water supply there would appear to be sufficient explanation of the method of infection of its milk. Its water supply is nominally from the pond near the church, but as a matter of fact it is without a supply of water, unless, indeed, the brook is to be thought of as furnishing such supply......Certain it is that the water of the brook, from the moment of its approach to the town and far above the dairy, became eminently fouled by the overflow of drains and other circumstance." Surely this is a case as gross as that of the previously-named farm at Great Coggleshall. And again, Dr. J. H. Garrett, in reporting on the sanitary condition of Cheltenham in 1893, says of the premises of two milksellers in that borough, "Here again, however, as in the former instance, a polluted water from a well upon the premises......was used for washing the milk utensils." And from this statement we see that if our milk supply be saved from pollution at the farm in the rural district, it by no means follows that it will not be exposed to dangerous contamination at our very doors. I was much struck on reading a report by Mr. T. W. Thompson, presented to the Medical Department of the Local Government Board in December, 1892, on the general sanitary condition of the York rural district, by the description therein given of the state of dairy farms in different villages in respect of their water supply. Thus, at one farm at Deighton the well was partly under a corner of the house and only some four feet from the foldyard, "the well was only dry steined, and doubtless served to drain the foldyard." Then, again, a farm at Fulford Water derived its water from a well close to the foldyard. At one farmhouse in the village of Copmanthorpe the only source of water supply was from a pump well in the middle of the foldyard, the water of which well tasted of the "oil" from the wooden covering of some adjacent creasoted red pine roofing after a rain storm, the first following upon the erection of the roofing. These, then, are some of the instances which were found to be existing in this district surrounding the city of York. Proximity of the farm wells to foldyards was a commonly-found defect in the district, and with the generally unsatisfactory state of the surroundings of wells all over the area the pollution of milk by the medium of water is not unlikely to frequently happen. In the neighbouring county of Lincolnshire we find, from the admirable report by Dr. Bruce Low on the Trent in relation to water supplies of the populations situate on its banks (No. 174), that in the rural district of Gainsborough, at some farmhouses on the river banks, "the water is pumped direct from the Trent to the house through a leaden pipe through the bank into the bed of the river." When one takes into account the highly polluted state of the Trent, subjected as it is in its whole length to gross excremental contamination from large aggregations of population, it is difficult to see how an unpolluted milk supply can be expected to emanate from the farmhouses where such a stream is the source of the water used for dairying purposes. I have already referred to the condition of this river, and need not here recapitulate the disgusting catalogue of pollutions to which it is open.

In illustration of the statement that it is not in the present time difficult to find a condition of affairs as bad as those just described, but existing in retail premises in our large towns and cities, I may mention the experience of the city of Edinburgh in the matter of the sanitary state of the milkshops there. In January, 1894, the Public Health Committee had their attention called to the serious condition of these premises for the retail sale of milk, inasmuch as it was found that many had their sleeping and living rooms in aërial communication with the rooms in which the milk was stored prior to sale. But worse still, many had these milk storerooms in aërial communication with waterclosets in the house, and in all it was found that some hundreds of the 760 retail vendors of the commodity had such dangerous intercommunications existing. It was, of course, not a state of things to be tolerated, and the Committee in the first place took steps to warn the poor people who eked out a living by the sale of small quantities of milk that either alteration of their premises must be carried out for cutting off the common atmosphere of the house from the milk storeroom, or they must desist from the selling of milk. As a consequence, a very large number of the shops were closed to the sale of milk, the people contenting themselves with the vending of the other articles which formed the staple stock in trade.

There is here, then, not only an instance of the deplorable state of things existing in a populous city, but also one of the value of mere verbal or written notice to even the poorest persons engaged in trade that they must seek to ameliorate the conditions under which they are carrying on their business to the danger of the community. But no one can read this account of the Edinburgh smaller milkshops without seeing to what a risk the city was exposed by reason of having a commodity so absorbent as milk open to the reception of drain air and other abominable stinks in a poor and populous quarter of the town. A food of such essential importance to the infantile population of a town cannot with impunity be allowed to be sold in a state of possible infectivity.

Turning to quite a different part of the country, I find Dr. Timbrell Bulstrode, in his report to the Local Government Board on the sanitary condition of Poole, giving an instance of a cowshed in that town in an insanitary condition. He tells us that it had not been whitewashed for a year, that it was dilapidated and dark in parts, and that immediately adjoining it was a huge accumulation of manure, at a higher level than the cowshed. In addition, the floor was defectively paved, and abutting upon the cowhouse was a double privy containing a vault which had not been emptied within the last year. He adds: "It was amid these surroundings that the milk supply of the customers was drawn from the cows."

I need not go further into details on this matter of the insanitary state of dairy farms and milkshops in our country, since if I say that the examples given of bad sanitary conditions are but typical of much that passes to-day as sufficient to warrant non-interference on the part of so-called health bodies, I think I have shown that we are still far from having arrived at that state of sanitary perfectness to which it should be our aim to attain. Milk is a food which is in great demand by the public at large, and especially in demand on account of the share which it takes in infantile feeding. Absolute purity of the commodity is accordingly correspondingly essential. It is bad enough to have a milk service which is far below the standard of the article as it is yielded by the cow, without the added horror of a supply mixed with water which is more or less of the consistency of sewage. If water of even the slightest doubtfulness is used for can-washing purposes, we have a right to demand that it be first submitted to boiling temperature; whilst if our farmer is so dishonest as to dilute his produce, we have at least good reason for claiming that the water paid for as milk shall be free from suspicion of contamination. Water of any kind at fourpence a quart is dear, but the pure article is preferable to the contents of a ditch or the oozings of a midden privy. And here for the moment I must leave this matter, hoping to treat of it again in my final recommendations.

CHARACTERS OF TYPHOID FEVER.

The compilation of the tabular account of waterborne typhoid outbreaks has not been without its interest in regard to special features portrayed by the disease in its numerous methods of manifestation; and it may not prove altogether unwise to briefly chronicle some of the more special notes which I have made in passing. Thus, at Ingham, in 1869, Mr. Netten Radcliffe, in reporting on a limited outbreak of fever (No. 14), which was undoubtedly due to water, said that there had evidently been two kinds of fever in question, the one unequivocal typhoid and the other a "continued" fever; that not improbably they were independent in their manifestation, although the phenomena were contemporaneous. Dr. Oglesby reported a case, to which I have already made reference in other connection, in which four patients were attacked in a village near Leeds in 1876 (No. 87) after consumption of the milk of a cow which had been able to obtain only "mere sewage" as drink, the cases lingering on for months, while the cow was herself getting thinner and thinner, at last refusing to graze. After she was got rid of the disease disappeared from the house, but convalescence was tardy, though ultimately complete. But during the tedious stages of the illness one prominent feature was that of partial convalescence "by fits and starts," one day cheerfulness another day lassitude, first playfulness then a desire for rest. The dangers attending on a tedious convalescence are well illustrated by what occurred at Penistone in 1879 (No. 103), where the first case in the outbreak of 42 cases was imported from Oldham, the patient having a long convalescence, and in his movements about Penistone proving a source of danger by reason of his infectious evacuations, two of the three principal water supplies of the place being then open to excremental contamination. The second case was only made known by reason of fatality.

One special feature of note is the epidemic diarrhœa which not infrequently precedes typhoid, not only that type which is waterborne, but also the disease when originating in other ways. For instance, I may refer to three examples, far removed in time and place, and in which two causes were specially operating, namely, Perth in 1880 (No. 112), King's Lynn in 1891 (No. 189), and Shildon and East Thickley in

1893, the latter being a case in which the disease was held by Dr. Bruce Low to be sewerborne, and disseminated also by means of milk polluted by sewer emanations. In all these three instances the disease of typhoid was preceded by epidemic diarrhœa, in Perth this milder disease being followed in the space of a week by typhoid, and at King's Lynn the preceding illness being in large amount, at Shildon it being also copious in its extent. It will be well, I think, that I should here insert a short extract from Dr. Low's report on King's Lynn as showing the character of the diarrhœal sickness which in that town was the forerunner of the typhoid outbreak. It will serve to illustrate this phase of much typhoid that has been of late investigated with the result of finding precedental diarrhœal illness in phenomenal amount.

"The recent epidemic of definite 'fever' was preceded by a severe and widespread outbreak of diarrhœa, which dated from the last three days of February—namely, 27th, 28th, and 29th. The diarrhœa of this outburst attacked all classes of persons and invaded most localities in the town. Sometimes every member of an invaded household suffered. In the majority of cases the illness lasted a week or ten days; and in many cases there were along with the diarrhœa symptoms elevation of temperature and sometimes sore throat. Early in March, with the waning of the diarrhœa outburst, more pronounced symptoms of typhoid fever began to appear, and such cases soon became numerous. Afterwards, during April, May, and early June, though fever cases continued to occur, they were in fewer numbers, many of them being secondary cases in previously invaded houses. On my arrival in King's Lynn.........I learned that at the beginning of the outbreak under investigation there existed some difference of opinion as to the nature of the malady which was manifesting itself in the borough. It appears that influenza had been epidemic in the neighbourhood about the end of 1891; and when at the end of February, 1892, a sudden increase of illness accompanied with diarrhœa appeared, the opinion formed by some of the medical men was that 'gastric influenza' afforded an explanation of the symptoms. Even up to the date of my arrival in Lynn this opinion was still held by some, who contended that typhoid fever did not and had not existed in the borough. In reference, therefore, to this doubt as to the nature of the current malady, I took the opportunity, in company always with the medical men in attendance, of visiting several of the patients who were still under medical treatment. From what I saw I had no hesitation as to the disease being typhoid fever. At the same time, it is not to be denied that a number of the earlier cases failed to present in a definite way the customary symptoms of this disease, and consequently I can well understand there having been, at first, hesitation as to diagnosis. But, however this may have been, later experience of the cases induced the medical men of Lynn, almost without exception, to agree in pronouncing the current fever to have been true typhoid fever."

With reference to the above I may say that it is by no means alone in the fact of the confusion of the beginnings of typhoid being diagnosed as influenza. In many cases of late this has happened, especially where the district has been suffering under influenza. One other feature of interest which struck me was in the report of Dr. Campbell Munro, the Health Officer for the county of Renfrew, who, in reporting on an outbreak of typhoid at Paisley and Johnstone in 1893 (No. 205), stated that Dr. Macalpine, of Paisley, had found in samples of water drawn from a reservoir, the water of which was implicated, the typhoid bacillus, and that all the conditions necessary for the propagation of the bacillus were present in a bog at one end of the reservoir.

Period of Incubation of Typhoid Fever.

The deliberations of the Clinical Society on this point are of great interest to us in connection with our subject, and it may not be out of place if I reproduce their short and pithy "Conclusions" (1892):

"1. The general conclusion to be drawn from all the facts is that the period of incubation in enteric fever varies within rather wide limits. The interval between exposure to infection and the development of distinct symptoms is probably most often twelve to fourteen days. It is not very infrequently nine or ten days, occasionally eight, and possibly even less. According to Dr. Murchison, 'it may not exceed one or two days'; but no case of the kind has been reported to the Committee. In rare cases it is prolonged to fifteen, eighteen, or even twenty-three days. Dr. Murchison thought it 'very doubtful if the incubation period ever much exceeds three weeks.'

"2. A person suffering from enteric fever is capable of conveying the infection to others throughout the whole course of the disease, from the date of the earliest symptoms of illness until convalescence has been established for at least a fortnight.

"3. An epidemic due to milk contamination may be expected to cease at or about the end of the second week after the arrest of the contaminated supply; but an epidemic due to contamination of a public water supply may not come to an end until the fourth week after the source of specific pollution has been removed. Where an epidemic can be traced to well water its duration may be very much more prolonged, and no general statement as to the probable date of its spontaneous termination can be made.

"4. Infection can be conveyed by fomites, and retained in them, probably for two months at least."

These conclusions are backed by much evidence bearing out their contentions, as very many of my readers will know; and it will not be necessary for me to enter into particulars as to that evidence, seeing that the volume issued by the Society is so largely known and so highly valued. But I will venture to refer to a somewhat remarkable outbreak which has been placed on record by Dr. Blaxall, of the Local Government Board for many years. At Fortune's Well, in the Isle of Portland (No. 164), there arose an outbreak of typhoid in 1886, after an absence of fifteen years, the infection being introduced by soldiers from Alexandria, 4 cases developing *en voyage*, and other 6 after landing, no one outside the regiment being attacked on board. In these latter circumstances it can only be held that infection was derived in Egypt, and, this being so, there comes the fact that the period of incubation varied from eighteen to as many as twenty-five days. Of the outbreak as it affected residents near a spring at Fortune's Well I need not speak; the facts in the appendix are clear to all as showing the source of the subsequent illness—some 80 cases—to have been due to polluted water.

Summation of the Case against Water.

I think I may leave here the case against water as an important agent in the causation of typhoid, though I could fain proceed with a subject so interesting and so vital to the health of the community. I have studied to be brief; but it has not always been possible to limit myself to hard and dry facts, one and another point demanding special prominence and notice. Nor do I hold to have by any means exhausted the subject of my report; indeed, I have, perhaps, rather only touched the fringe of the matter, seeing that the question of water in relation to disease is too large to treat of within the scope of the British Medical Journal in the way befitting the importance of the subject. But let it suffice that I have endeavoured to show in what way I consider water to have played its part in the causation and dissemination of typhoid as we have been used to see it in our own country. It will have been observed that I have not travelled beyond the confines of the United Kingdom for instances of waterborne typhoid, deeming it best to confine my report to the British Isles. And truly I have not found much trouble in discovering the material on which to base my conclusions. In the period of less than forty years which I have selected for the purposes of my summary tables I have, as already pointed out, laid under contribution the reports of no fewer than 206 distinct outbreaks in which water has proved a factor in the spread of typhoid fever; and it is by no means in the earlier years of this period that I have found the disease thus to be prevailing. Analysis of the chronological column displays the significant fact that in the last fifteen years as many as 105 of the total find place. The reason of this I shall hope shortly to show.

In having thus brought together what I may claim to be a unique collection of waterborne outbreaks, I make known my indebtedness to the literature emanating from the Medical

Department of the State, at Whitehall, the reports of which Department I have, in an especial manner, laid under contribution in my summary. And again, it will be noticed that in illustrating my points I have in large measure confined myself to references to reports issued from the Public Health Department, not for the reason that there are not reports from others to which I could have referred, but because the inquiries held by that Department have in most cases been carried out with an amount of detail and width which has been next to impracticable on the part of local health officers, hampered as they are with much work, and meagre as their experience has for the most part been on matters of disease causation when elaborate and sustained inquiry has been called for in the elucidation of some obscure point. This is no discredit to the local officers, but it is a reason for the prominence which is here given to reports issuing from Whitehall. It has been impossible for me to escape from the fact that nearly all the great epidemics of typhoid fever which have occurred from time to time in our country, have called for the intervention of the Department of State Medicine. And one can well see that a body of men trained as is the small body at Whitehall must needs have a grasp of subjects connected with their particular branch of research far and away beyond the comparatively circumscribed experience which pertains to the local officers of our sanitary districts, especially in view of our present pernicious system of short tenure, bad pay, and do-the-least-possible policy. And I would here pay my humble tribute to the excellent series of reports which continue to issue from the Medical Department at Whitehall, concerning local prevalences of infectious disease in England and Wales—a series unique in the whole world, and unsurpassed by any nation. Under the successive leaderships of Sir John Simon, the late Dr. Seaton, Sir George Buchanan, and more recently and at the present moment of Dr. Thorne Thorne, we have seen immense strides made by the sanitary bodies of the country towards the perfecting of our sanitary system; the progress being in no mean degree due to the indefatigable labours of these leaders of sanitary science to educate the people to a just idea of the importance of all that goes to make health, alike for the individual and the people at large. The careful and elaborate reports which emanate from the pens of the medical staff of the Local Government Board are worthy of emulation, and they were never abler or more appreciated than to-day. These reports find an honoured place in the library of the British Medical Association, and I acknowledge the vast assistance which these classic documents have been to me in my present paper, easing my inquiry to no mean extent by their clearness and precision.

There may be found those who will attempt to argue that waterborne typhoid is a watchword of a particular section of the public during a comparatively recent period; that the theory is one that has not received the approval of some men of unquestioned scientific attainments. It may be so to some extent. But why? As to the first point I agree that it is in the last fifteen years or so that the theory has come into greater prominence, but the reason is not, to my mind, far to seek. Prior to and during the seventies, whenever an outbreak of typhoid fever had to be investigated, there was as a very general rule a desire on the part of the Government to show up the insanitary circumstances with which the disease had been associated rather than to elaborate the inquiry with a view of differentiating between the potency of one and another possible cause of the disease; so that while there was seldom little doubt as to the relation of the disease to insanitary conditions in a general sense, there was not often any very pronounced thesis advanced as to the part played by any one of the many possible causes. True, the summary tables show that my statement can be brought in question in many instances, but taken as a whole the inquiries of earlier years did not proceed to an elucidation of the precise manner of propagation of the fever. It has thus come about that I have waded through numerous reports to no purpose, seeing that though there was undoubted possibility that water had been a factor, more or less special, in the causation of a particular epidemic, there was no definite and detailed consideration of the part played by water. Notable cases wherein the disease was traceable to water are of course to be readily found, or my summary table would not have assumed its present bulk in regard of the earlier years of the period covered. But it is apparent to me that in the latter fifteen years, roughly, of the period there has been a manifest and ever growing tendency to push the matter of cause as far as possible in order that the local health body might be enabled to lay their hand, so to speak, on the spot and heal it, the weakness of their sanitary defence being thus held up to the light of publicity, and its strengthening as matter of course thus more easily brought about. Indeed, it is this excellent method of holding up recalcitrant sanitary authorities to the public gaze that has undoubtedly done much to stimulate them to sanitary activity. Next to threatened dissolution there seems to be no step so calculated to stir a body into activity as public opinion.

In this way, then, has it come about, to my mind, that we hear to-day so much more concerning waterborne typhoid than we did twenty years ago. Had inquiries always been conducted on the plan now commonly adopted at Whitehall, I do not for one moment doubt that my summary tables, already lengthy, would have been much distended from their present shape. But the labour entailed in the process of exclusion of those outbreaks in respect of which the reports were so meagre as to necessitate omission of them from my *précis*, has been very great; how great may to some extent be gathered from the fact that in the four years 1870-73 the Medical Department at Whitehall chronicled no fewer than 148 inquiries made by their staff into separate outbreaks of typhoid fever; and it was essential that all these, or such majority of them as found place in accessible reports, should be studied for the purpose of seeing in which of them water had been shown to have had a part in the causation or spread of the disease. But however loud is the outcry in some quarters on the subject of waterborne typhoid, I hope that the most sceptical hitherto on the matter will have been convinced by a perusal of the preceding pages of this report that the case against water as a disseminator of typhoid fever has been fully made out. My aim has been to place the question beyond the pale of doubt. I shall be more than rewarded if I have succeeded in my object.

What have the pages of my report shown? They have shown typhoid fever caused and spread in a variety of ways by the agency of water; they have testified to the fact that water can become polluted at its source, on its way to the consumer (alike before and after entry to the distributing mains), and within the precincts of the domestic dwelling. We have seen outbreaks caused by polluted wells, by sewage-contaminated rivers and streams, by water services which have received the drainage of manured fields, the sewage of whole villages, and innumerable excremental pollutions over the areas of the gathering grounds; by the careless laying, in close proximity and in badly jointed fashion, of watermains and sewers (the former sometimes even passing through the latter); by the washing of milk cans with polluted water; by the mixing of milk with water equally polluted; and by numerous other ways, all of which are set out in my report under their respective headings. I need not here enlarge on the matter; let the facts in my tables and the illustrations therefrom, with which I have striven to picture my several points, suffice.

For the rest, it seems necessary only that I should consider briefly the points which the foregoing pages show to be those which should engage the attention of sanitarians in the future if a continuance of the constantly-recurring outbreaks of waterborne typhoid fever is to be prevented.

The Outlook: Some Points for Future Consideration.

My study of the subject dealt with in this report has led me very strongly to support the theory that sees in the soil the natural habitat and breeding ground of the bacillus of typhoid fever outside the human body. This belief in nowise lessens my regard of the disease as being largely caused by water—rather the reverse. We are most of us aware of the possibility of transmission of tetanus to man from the lower animals, as, for example, by a kick from a horse. Yet the bacillus of tetanus lives in the soil. It is taken up by the hoof of the quadruped, and the animal is thus made the medium of transmission of the malady induced by the organism. I do not myself incline to the belief that the bacillus of typhoid fever is conveyed to man by the medium of water, save in so far as the bacillus has gained access to the water by excremental pollution from soakage or the like. Certain it is to my way of thinking that the essential element in the prevention of waterborne typhoid fever is cleanliness. All that goes to cause pollution of the soil tends to foster disease. No point is so strongly or so persistently brought out in the history of typhoid fever occurrences in our country as that dirt and disease go hand in hand. Only in the case of rivers does man seem to place his excrement directly into his own or his neighbour's drinking water, but he does not scruple in only too many instances to so dispose of his filth that it must in the natural order of things find its way to that drinking water. It is not alone in our rural and sparsely-populated districts that such disposal takes place; it is just as common to see people harbouring up their filth in proximity to dwellings and local water supplies in our towns. Those abominations which to-day persist in so many of our towns—leaky and huge midden privies, uncovered and ill-constructed ashpits, cesspools permitting soakage of their contents, no one knows where—all these and more are the accompaniments of daily life in scores of towns. And where town populations have the good sense to so dispose of their filth as not to poison the air they breathe or their local wells, too often we find them in their selfishness and negligence endangering the water service of a vast aggregation of people in some adjacent city or borough by so ridding themselves of their excrement as to pollute a gathering ground or a stream or river used for purposes of domestic water supply.

WHAT IS THE REMEDY? I WILL ATTEMPT THE ANSWER.

1. *Local Water Supplies.*—I would see carried out in their entirety, so far as is at all possible, the recommendations of the Committee appointed by the Local Government Board in 1875 to inquire into the various methods of sewage disposal, where they suggest ridding the country of cesspools in the midst of towns; and would also see cesspit middens improved off the face of the earth. I would see the conclusion of the Society of Arts Committee on the Health of Towns of 1876 carried out—namely, that all middens, privies, and cesspools in towns should be abolished by law, feeling that these disease-disseminating abominations as we permit them to-day are annually costing the country enormous sums by these very qualities of disease provocation. To this end I would see the statutory duty of sanitary authorities to make provision of proper sewers for their districts enforced in all cases where sewerage is practicable. There will probably always be found reason for retaining some form of storage of excrement and refuse near dwellings for a time in the case of rural localities, but only in such places. And here we see the wisdom of the excellent series of model by-laws which have been drawn up by the Local Government Board for the guidance of local authorities who desire to secure for their constituents the minimum of danger from use of these receptacles. Thus the by-laws prescribe the method of construction and position in respect of water supplies of such receptacles as midden privies, ashpits, earthclosets, cesspools, and the like; and it will be well when by-laws come to be adopted by sanitary bodies, and in turn enforced where thus adopted. It is one thing to have an admirable series of safeguards at hand, and another to see to it that those safeguards are made to apply. It will, however, not be enough that cesspools and such like be abolished; it will be necessary also that the old disused forms of excrement disposal be so done away with as not to prove dangers by reason of their condition at the time of abolition. So I would see the application of some powerful disinfectant to the receptacles when emptied finally, as well as the complete filling in of the space occupied by them, in such manner that no danger shall accrue to water supplies by reason of future soakage of filth left in the middens, etc.

But there is another side to this question of local supplies, and that is that wells from a subsoil liable to pollution should in no wise be made use of as sources of water supply. The soil on which many of our towns are built has been subjected to gross contamination for many years, and it is not to be thought of as likely that the mere abolition of cesspools, and so forth, will at once render safe the abstraction of water from wells sunk in their proximity. Indeed, it may well be that no return could with safety be made to wells circumstanced as they are in some places; whilst in others it will take a long time to rid the soil of its accumulated filth. It is, however, obvious that many wells to-day in our country are not only so circumstanced as seriously to threaten the health of consumers of their contents, but also that the wells are constructed in such fashion as to permit of soakage from the surrounding soil into them, both surface and subsoil drainage. It should therefore be the aim of all sanitary bodies to secure the internal lining of wells being so finished as to prevent the ingress of water from any questionable source. I have already given Professor R. Koch's method of securing wells against pollution. I say nothing concerning it. But I do impress upon health bodies the necessity of seeing to it that wells in the areas of their jurisdiction are not allowed to remain in a condition favouring their pollution by water of doubtful quality. The further danger of contamination of well water by reason of rain storms and resulting floods is one to be thought of; and one that calls for the proper construction of well mouths, lest they be subjected to periodical overflow by surface water of polluted character. It would seem, then, that middens and other similar structures will be at times a necessity, and it also seems that wells will be still more of an essential element in rural life; the condition of cleanliness necessary to guard against pollution of the one by the other should be aimed at, therefore, in all places where these methods of disposal and supply obtain.

The sanitary authorities of rural districts have an excellent power in their hands for the inspection of water supplies in the areas over which they have jurisdiction under Section 7 of the Public Health (Water) Act, 1878, and it would be well if more use were generally made of the power thus conferred upon them. Not that I would be thought of as holding the view that rural water supplies are not subject to scrutiny; what I have in my mind is the desire to see practical use made of the inspectorial duty cast upon rural authorities. It will often happen that action can be taken on inspections carried out with the object of securing wholesome for impure supplies, and much more can be done in the direction of closing polluted wells and the like than has been effected in the past. I am of course well acquainted with the difficulties in the way of securing the closure of polluted wells, and I would welcome the alteration in the wording of Section 70 of the Public Health Act, 1875, from "injurious to health" to "dangerous to health" in accordance with the prayer of the Society of Medical Officers of Health and of Public Analysts presented some time back to the Local Government Board. The section as it stands has ofttimes proved an obstacle in the way of closure of wells undoubtedly "dangerous" to the health of consumers of their contents.

Before I leave the region of domestic supplies there is one other point which I would like to name, and that is the danger of continuing anywhere the flushing of waterclosets directly from water mains. I know that the practice is by no means so common as it was twenty years ago, but it is far from uncommon even yet. Not only should a cistern be used for the purpose of flushing, but a separate cistern to boot, since it may well be that a cistern common to the whole house will be contaminated by the passage of air from the closet pan up the pipe, the liability to this form of pollution being obviated by the intervention of a separate flushing cistern. It may be argued that a sanitary authority has no power to compel the provision thus of flushing apparatus to existing closets. I am only sorry that it is so. The sooner the omission is rectified by the adoption of the Public Health Acts Amendment Act of 1890 the better. At least let health bodies see to it that all closets hereafter erected are so furnished. I would also see the covering and frequent cleansing of house-supply cisterns insisted upon.

I know that in thus leaving this important section of domestic water service I am going from it with but poor attempt to emphasise the needs of the community at the present time for the perfecting of such service; but if my remarks attract attention to some of the most pressing wants, I shall have achieved something. The foregoing pages testify to the terrible consequences of neglect of elementary principles of domestic cleanliness in the past; let them enforce the lessons so slow of being learned.

2. *Public Water Supplies.*—Here I touch upon a much larger question. It is one that has already received such extensive consideration at my hands that I hesitate to say much more upon it. But still I am persuaded that many points need to be treated under this heading before we can hope to see waterborne typhoid fever exterminated. One of the foremost questions of to-day is that of river pollution. The importance of freeing our rivers from their sewer-like condition is not to be gainsaid. A perusal of my summary tables will at once enable my readers to perceive the enormous interest which the public have at stake in seeing that our waterways shall be preserved from excremental pollution in so far as they serve as sources of water supply. A great stride has been made of late by the creation of joint committees for the prevention of such pollution. It is to be hoped that such bodies will be multiplied, and that they will aim at the greatest good attainable by securing the co-operation of all the manufacturers in the district within the area for which they have been appointed to act. Such bodies, if really in earnest, can, I am quite sure, do much to free our rivers from contamination. At present it is no uncommon thing to learn of towns drawing water for domestic purposes from a river which higher up is receiving the untreated sewage of a large population, and the trade effluent of manufacturing districts. I would have all waterways which are sewage polluted or rendered doubtful by the flow into them of trade refuse entirely done away with as sources of water supply. And again, I would wish to see the disposal of sewage enforced in such manner as to preclude the possibility of direct egress of sewer contents to any river or stream that is not tidal. The Rivers Pollution Prevention Acts have been signal failures so far as their practical results show. If our rivers are to continue to serve our tables with drinking water, let them be absolutely free from the contents of our waterclosets, at any rate in their crude forms.

But I wish here to chronicle my desire to see the State stepping in and enforcing that the sewerage of all towns shall be so carried out as to avoid contravention of the Rivers Pollution Prevention Acts. I do not think the State should in anywise countenance the disposal of sewage in a way likely to render those Acts inoperative in any sanitary district. Either let our rivers and streams be kept from all manner of pollution, or let them be frankly held to be unusable for purposes of drinking water, even after filtration. Engineering experts tell us that the effluent of sewage matters can be rendered safe for the purposes of ingress to our waterways; then by all means let the country see to it that our rivers be no longer allowed to remain common sewers.

There seems to be no safe middle course. While rivers and streams are thus dealt with, let all use of canals for drinking purposes be also absolutely prohibited. The gross sources of pollution to which they are subjected speak for themselves; for not only are they the receptacles of all sorts of abominations from the banks, but they are open to extremely dangerous contamination by means of the immense floating population always residing upon their waters. The same may be said of many of our navigable rivers.

Equally open to pollution are only too many of the gathering grounds of our public supplies. There can be no excuse for the delivery to the distributing mains of water drained from a catchment area on which are situate villages and other aggregations of populations, with their varying methods of excrement disposal, such as midden privies, cesspools, and even sewerage systems, inclusive of direct disposal of crude sewage on land draining to the storage or service reservoirs. Yet such things are happening to-day in our land. We find such other elements as churchyard drainings, heavily manured fields with natural drainage to the water conduits, and the like. To my mind, all gathering grounds should be freed from anything worse than the mere droppings of pastured animals, since whilst we permit manure, often of human origin, to be deposited within the catchment area, and excrement disposal such as is incidental to populations in villages, farmsteads, and so on, to persist in positions whence they assail the purity of our drinking water, we wilfully court disaster. Where public supplies are in the hands of corporate sanitary bodies the question of gathering grounds is made easier than where companies are in possession of the works. And for this and many other cogent reasons, I would see the way made smoother for enabling sanitary authorities to purchase such works. At present, Section 52 of the Public Health Act, 1875, is so encumbered as to be virtually a dead letter for the purpose of freeing sanitary bodies from the necessity of taking water at the hands of any company that may chance to have rights of supply in their district.

Altogether, apart from the question of pollution of water services by visible media, there is the important consideration of the construction and method of laying water mains, especially where they come in close proximity to sewers. I would see much greater care bestowed on these matters than is seen by the pages of this report to have been the case in too many instances. Badly jointed mains may well become the receptacles of any filth that may happen to be in the neighbourhood, and it is well known that water mains, even when "running full," are able to take up extraneous matters by insuction. Where, then, sewers are placed close to mains, or the reverse happens, the most exceeding care should be bestowed on every detail to secure that the water shall be free from the possibility of sucking up the leaking contents of the sewers. When sewers are laid at a higher level than water pipes this care will have to be correspondingly still greater, not only in the first laying of the pipes, but in the maintenance of the plant. The relation of sewage to water used for domestic purposes does not, however, cease when the sewers have been properly laid and egress of their contents underground prevented in the proximity of water mains. There is the factor of disposal of the sewage to which I have already referred.

Before I leave the subject of water mains, let me say that I would like to see all ball hydrants done away with. They have more than once been seen to be associated with prevalence of typhoid fever in districts served by them, and they would, to say the least, seem to be a danger to the purity of the water, even if by no worse than road detritus, but, as we know, at times also by the contents of ashpits, privies, middens, and the like.

In the matter of filtration I am much afraid we come off very far short of that point of perfection to which it were well that we should attain. The theory now advanced concerning the filtering of drinking water, which eats at the very heart of our preconceived notions as to the treatment to which our filter beds should be subjected, has also brought with it the statement of the only position which it is safe to adopt, if we are to be free from the danger of recurring outbreaks of typhoid fever by reason of our water supply becoming polluted in a manner not to be rendered harmless by our prevailing methods of filtration. To such of my readers as have not studied the paper of Professor R. Koch on Water Filtration and Cholera,[1] I would say do so; and I would further lay stress on the rules which are therein laid down for the frequent and regular bacteriological examination of water from each separate filtering basin and before the water has been allowed to pass into the general storage reservoir, as also to the rule as to the construction of the filter beds in such manner that improperly filtered water can be at once removed, not being allowed to mix with the other water to be delivered to the distributing mains.

I have previously stated the rate and quality of the filtration which Professor Koch would see universally adopted, and I need not here further pursue the matters; but I could wish to see our water companies and corporations appointing as their chief engineers men of standing in regard of bacteriology as applied to the examination of water. Much as I would like to dwell upon this important portion of my subject I must hasten on, leaving my readers to further study the current literature if they feel interested in the questions at issue.

Water Supplies to Dairy Farms, Cowsheds, Etc.

This is a matter of vital importance that cannot be well overlooked. The question of the water supplied to milch cattle by no means receives the attention which it undoubtedly deserves. It would seem to be the commonly accepted idea that cattle may with impunity be allowed to drink of any and every kind of water. It is not so. Evidence testifies to the contrary.

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[1] Professor R. Koch on Cholera. Translated by Geo. Duncan, M.A. Douglas, Edinburgh, 1894.

Mr. Shirley Murphy has stated, in a paper in the *Practitioner* in 1889, that he would like to see the drinking water of cows outside cowsheds from ponds fed by springs and fenced round to prevent fouling. So, too, I would wish to see care paid to the purity of the water with which cows are regaled, alike in the pasture and the cowshed. Indeed, the water furnished to housed cows is in need of much more careful supervision than is carried on. The cases which appear in my summary tables in which water-polluted milk has played a part in the dissemination of typhoid fever speak of the want of ordinary attention to the necessities of the case. The water supply of many of our country farmsteads is a disgrace to the land and a constant menace to the milk trade. But this is only one point in which much still remains to be done in the way of securing our milk from the potency of harm which frequently attaches to it, and must form the subject of another paper, seeing that the specific pollution of cans, milk, and other dairying plant and produce by fever-contaminated water is but one phase of the dangers to which milk is exposed. Suffice it that the exercise of a minute inspection of our dairy farms and cowsheds and milkshops is called for, and much more needs to be accomplished by our health officers and nuisance inspectors in the future than has been done in the past. Regulations have of late years been increasingly brought to the notice of sanitary bodies, but their adoption, and especially their uniform enforcement, have not been correspondingly in evidence. The relation of the milk trade to the public health is too intimate to admit of any half-heartedness in the method of control of the varying businesses connected with it in so far as the health of the community is affected or is at all likely to be affected.

CONCLUSION.

My task is now all but finished, imperfect though it be; but if it serve to impress upon our health bodies and the community the lessons which may be learned from the history of waterborne typhoid fever in our country, and if the lessons so taught bear fruit in the direction of added care to the important matter of water supplies, then my task will not have been undertaken in vain. But it cannot be too strongly pressed home that the future exemption from the disease much depends on the attitude of the people towards matters sanitary, since public bodies of whatever nature are after all but the embodiment in brief of the public whom they represent. It is undeniable that the public ear needs to be caught before any reforms can be carried out; and in matters affecting the health of the community the people need to be educated in no small degree, especially having regard to the fact that the public purse-strings are involved. If there be one point upon which misconception arises more than another, it is the supposition that money is wasted when it is spent on sanitary reforms which are not clearly indicated by the advent of absolute disaster as a consequence of their previous neglect. The lesson has still to be widely learned that the remedy of sanitary deficiencies, the provision of pure water, proper methods of excrement removal and disposal, and the adoption of all practicable means for the prevention and stay of infectious diseases, are among the most sound investments which can be made by the individual and the community. When any nuisance touches the welfare of any one person or household an outcry is at once made until the matter is settled; but where the health, and therefore the happiness, of a town is not seriously threatened in a visible form, but is nevertheless endangered by the neglect to provide that which experience has shown to be essential to actual freedom from possible harm, then it is that the ratepayers often rise and protest against the expenditure of public moneys on a matter of "possible" concern for their health. But although this is so, still to some extent there can be no denying the fact that the people of England are awaking to some sense of their obligation to the advance of sanitary science for their present comparative exemption from the ravages of those diseases of a preventable nature from which our country has suffered in time past.

An apparent paradox has now been for some time promulgated to the effect that cholera in this country saves more lives than it costs, but the assertion is true. All sanitary measures that go to lessen the likelihood of cholera-spread go also to lessen the chance of spread of diseases which are disseminated in like manner to that plague, and typhoid fever is most certainly one of those diseases which are thus held in check. Yet when cholera threatens our coasts, there is but little difficulty in securing the co-operation of sanitary bodies and the public in carrying out those measures which are thought to be necessary. But it must be held in mind that cholera and typhoid fever are scarcely to be mentioned in the same breath for frequency of occurrence and wideness of misery and death arising therefrom. The latter disease yearly claims its thousands of victims to attack, and its hundreds of lives. Not so cholera nowadays; if half a hundred cases are heard of, and a dozen deaths are registered, the country is up in a state of panic, and the floodgates of suggestion and of costly piecemeal activity are flung wide. If the relative importance of the cost to the country year by year of these two diseases were any criterion of the attention to be paid to them, then we should have great hopes of seeing the time come quickly when typhoid fever would be reckoned as one of the scourges of a past generation; and its appearance looked upon in much the same way as cholera is now regarded.

But there is to my mind another side to the matter, and that is that if sanitary bodies are the representatives of the public they are also the bodies charged with administering the laws relating to the health of the community, and as such have a responsibility cast upon them of seeing to it that the laws are so administered as best to advance the interests of their constituents. To this end the State has sanctioned the appointment of sanitary advisers, and has also established its own health department. It will be well when our sanitary bodies see in its proper light the seriousness of neglecting this responsibility, notwithstanding that the ratepayers are averse on general grounds to the expenditure of money on measures of sanitary improvement. There are many ways in which these bodies can secure improvement in their districts without overburdening the rates, as, for example, by borrowing money with power of repayment in a number of years, so that interest and capital are in some degree paid by a succeeding generation enjoying the benefits provided by their predecessors. I regard the elementary matters of pure and adequate water supply, proper and sufficient sewers, and proper means of sewage disposal as essentials for every place of any pretensions to the name of town; whilst many rural districts possess aggregations of population for which they are none the less essential. I would see their provision enforced in all such places. Sickness is just as costly as cleanliness and much more disagreeable.

There is now an additional incentive to sanitary authorities to properly perform their statutory duties, seeing that county councils have at any rate got the power of calling upon the Local Government Board for inquiry where any district authority have made default in regard of their duties; and there can be no doubt that the power is no slight one, since the exercise of it may mean exposure to the public of the shortcomings of the health body, with possible outlay for work which could have been the more economically done by degrees when its necessity was first pointed out. There can be little doubt that county councils have in their sanitary officials a means of keeping them well informed as to the state of the administrative county, while the districts themselves will have the benefit of counsel from the county officials. I have already, in a paper which appeared in the BRITISH MEDICAL JOURNAL of July 15th, 22nd, and 29th, 1893, on the subject of extended powers needed by county councils, pointed out the directions in which those bodies could be made more useful still to the counties which they serve. It certainly seems that they are becoming alive to their position towards local authorities, and the stimulus thus given to those authorities will not be without its result on the healthiness of the country. The great lack of many of our county councils to-day is a medical adviser. The omission to appoint such needs to be rectified.

But there is still another body to which, after all, we must look for much that is to place our country on the basis of sanitary perfection to which we would all see it attain—I refer to the Local Government Board. The past amply testifies to the good work carried out by this State Board of Health. The influence on the present sanitary position of England of the action of this Board has been most marked. But even so, I do not think I shall err if I place the Medical Department of the Board in the foremost position, as having contributed to the advance made in the last twenty-five years. I need not here dwell on their achievements. I will satisfy myself by a reference to one piece of work undertaken during the last two years under threat of cholera invasion. The work was the special *Cholera Survey* of numerous sanitary districts throughout the country. The public press has amply demonstrated the help which this survey has been to the localities visited; and the mass of information got together at headquarters as a result of these local visits must be enormous. My chief reason for naming this matter is to ask the questions: Why a "cholera" survey only? Why not, indeed, a "sanitary" survey also? If the survey has, as we know it has in many cases, demonstrated the unreadiness of districts to resist cholera, why limit such a useful measure of supervision to cholera seasons, seeing that typhoid fever will spread where cholera can find a breeding ground? Is such a duty to be left to county councils, and if so will they perform it in a manner likely to prove generally useful? The State now has its regular school inspection, its periodical workhouse visitation, its biennial public vaccination inspection; why not its annual, biennial, triennial (or even its irregular, but constant) inspection of sanitary districts for the purposes of ascertaining the shortcomings and the remedial measures necessary in regard of the sanitary state of our country? And this not alone in England. Surely such a Governmental supervision of our local authorities would be a heavy lever in the hands of the State towards securing uniform cleanliness alike of air, soil, and water.

However it be accomplished, certainly it would seem to be of paramount importance that a country held up, and even holding itself up, as a pattern in matters sanitary, should strive to secure the prevention of preventable diseases, of which class typhoid fever is typical. It will undoubtedly be a costly piece of work, but the end in view more than justifies the adoption of the essential measures.

APPENDIX A.

DR. KLEIN'S BACTERIOLOGICAL EXAMINATION OF WORTHING WATER, 1893.

Methods of Examination.

(*Appended to Dr. Theodore Thomson's Report on the Worthing Typhoid Fever Epidemic of 1893.*)

The methods of examination resorted to were as follows: With the view of ascertaining the quantity of micro-organisms per cubic centimetre of the water under investigation, the ordinary method of plate cultivations was employed. This plan consists of adding to nutrient gelatine in a fluid state a small quantity of water to be examined (the amount employed varying from 1 c.cm. to a fraction thereof), shaking the mixture so as to aid distribution of the water throughout the gelatine, and then pouring the mixture on plates. These plates, on which the gelatine mixture solidifies, are then transferred to an incubator, and maintained at a temperature of 20° C.; and by subsequent observation the number and nature of the organisms that grow on the gelatine are ascertained.

Another method was resorted to in searching for particular microbes in water from a given source, and for the following reasons:

(*a*) The bacillus coli and the enteric fever bacillus, when present in drinking water, exist there for the most part in relatively small proportion. Thus, if only a small quantity of water, such as 1 c.cm., be examined, it is likely that the organism, sparingly present in the total bulk of water, may not be present in a small sample, although present in a larger bulk.

(*b*) If the number of other micro-organisms amount to several hundreds or more per c.cm.—and this is usually the case when water is unfiltered—there is risk that the numerous colonies of these may on plate cultures obscure and prevent recognition of scantily present bacillus coli or enteric fever bacillus.

(*c*) One of the bacteria most frequently found in water is the bacillus fluorescens liquescens, which grows much more rapidly than either the bacillus coli or the enteric fever bacillus, and liquefies gelatine very quickly. Abundance of the first-named bacillus in the water under examination would accordingly, by liquefaction of the gelatine mixture, tend to prevent detection of either of the last-named bacilli. With the view, therefore, of overcoming these difficulties the following means were adopted:

1. A considerable bulk of water (from 1,500 to 2 500 c.cm.) was submitted to examination. For this purpose the quantity to be examined was passed through a sterile Berkefeld filter, which retained on its outer surface all or nearly all the particulate matter contained in the water. The matter thus retained on this outer surface was then brushed with a sterile brush into 20 c.cm. of sterilised water and mixed therewith. Of this mixture 1 c.cm. was added to each of a series of gelatine plates and broth tubes.[2] Accordingly these tubes and plates contained all or nearly all the particulate matter of the total quantity of water selected for examination.

2. To prevent obscuring of the bacillus coli or the bacillus of enteric fever by other organisms that grow more rapidly than they, or that soon liquefy the gelatine, a small quantity of phenol was added to the culture media. For this purpose a 5 per cent. watery solution of phenol was used, and this solution was added to the culture media in the proportion of 1 of the former to 100 of the latter. The added phenol, which does not interfere in any way with the growth and multiplication of the bacillus coli or of the bacillus of enteric fever, exerts a marked inhibitory effect on such water bacteria as bacillus fluorescens liquescens, the proteus vulgaris, and others; and, by retardation or suppression in this way of growth of these latter organisms, better opportunity is afforded of detecting in waters examined the presence of the bacillus coli or of the bacillus of enteric fever.

The gelatine plate and broth tube cultures thus prepared were incubated at a temperature of 20° C. and of 37° C. respectively. From growths of the bacillus coli or the enteric fever bacillus obtained in these ways subcultures were made in the ordinary manner.

Features characteristic of Bacillus Coli and of the Enteric Fever Bacillus.

Bacillus Coli.	Enteric Fever Bacillus.
Shorter and less mobile than the enteric fever bacillus.	Longer and more mobile than the bacillus coli.
Forms gas bubbles in gelatine shake culture.	Does not form gas bubbles in gelatine shake culture.
Curdles milk in 1 to 2 days at 37° C.	Does not curdle milk.
If grown in broth for several days forms indol.	Gives no indol reaction when grown in broth.

The above tabular statement embodies the chief distinctive features of the bacillus coli and the enteric fever bacillus, derived respectively from the contents of the healthy human intestine and from the tissues of enteric fever. Other points are as follows: In gelatine stab culture and in gelatine surface cultures these bacilli are alike in general appearance save in two respects, namely, (*a*) that the bacillus coli grows faster than the enteric fever bacillus, and (*b*) that in gelatine stab culture the former organism forms on the upper surface of the gelatine a larger plate-like growth than does the latter. On gelatine plates both organisms form on the surface of the culture medium colonies which present the appearance of flat, crenated, or irregularly outlined patches, thinner at the periphery than at the centre, translucent by transmitted light, greyish by reflected light; while colonies of both organisms, growing beneath the surface and embedded in the gelatine, are rounder than surface colonies, and appear of a brownish colour by transmitted light. Neither organism liquefies gelatine. Their growth on agar and on potato affords no definitely distinctive feature; although, as a rule, the bacillus coli forms on potato a brownish growth, while the bacillus of enteric fever forms on the same medium a colourless growth.

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[2] Beef broth; alkaline; with 1 per cent. peptone and 1 per cent. salt added.

Summary Tables of Facts Relating to 206 Outbreaks of Typhoid Fever in Great Britain and Ireland during Thirty-one Years, 1863-93.

1	2	3	4	5	6	7	8	9	10	11	12	13	14
No.	Date of Outbreak.	Locality.	Reporter.	Total Number of Cases.	Deaths.	Population of Invaded Locality.	Number of Persons Supplied by Suspected Water.	Number of Cases amongst Drinkers of Suspected Water.	Percentage of Total Cases.	Exciting Cause of Outbreak.	Circumstances Implicating Water.	Observations.	Reference.
1	Early 1863	Wing	Dr. Ord, P.C.O.	140	12	1,050	1 household	Whole of inmates	—	Shallow well in the middle of a small muddy yard, walls of loose brick, not puddled and admitting surface infiltration; 8 yards distant was a cesspool connected with a public sewer	This well served only one of a row of houses. This house, near the middle, and having a large number of children, was the only house attacked, the fever seizing every inmate	Fever was general throughout the village, its existence elsewhere being associated with various insanitary circumstances	Report of Med. Officer, P.C.O. 1863.
2	March and April, 1863	Hensingham (Capel Terrace)	Dr. Bristowe, P.C.O.	—	—	Some 40 households	All	All	100	Drinking water from the surface soil, distinctly impregnated with soakage from pigstyes, etc.	Outbreak of a sudden and severe character occurred in this row of some 40 houses invading all those that were occupied	Later on fever became generally prevalent in Whitehaven and St. Bees, but not in any direct association with water service	Report of Med. Officer, P.C.O. 1863.
3	Dec., 1863, to Feb., 1864	Redbourn, Lincolnshire	Dr. Hunter, P.C.O.	18 households	6	—	—	12 households	67 of invaded households	A row of houses (Pratt's Houses) of miserable structure and sanitary surroundings, with privies and wells compactly arranged in the yards behind, the well of the houses initially invaded visibly receiving surface drainage, in addition to infiltration; it had been abandoned spontaneously by the consumers soon after the fever appeared. The four houses first invaded used one privy and one well in common	Of the 18 households affected, the first 8 were all in the same row of houses wherein the initial attack occurred, 5 cases arising in this one house; and later on 2 members of another family succeeding these tenants were attacked. All the deaths in this group of cases (Col. 9) were of consumers of the water of the well supplying this house	With one exception the cases of fever distributed in the village occurred subsequently to the invasion of the 12 households in Pratt's Houses	7th Report of Med. Officer, P. C. O., 1864.
4	June, 1864-66	Page Green, Tottenham, Middlesex	Dr. E. Seaton, P.C.O.	106	2	80 or 90 houses	About 30 houses	All	100	Water supply in parts of district from shallow wells 7 or 8 feet deep, sunk in porous gravel, and manifestly liable to surface and sewage contamination, as analyses showed. For example, in one case the water pumped from a well smelt distinctly of carbolic acid which had been poured down the yard sink	With the exception of 4 cases, concerning which no information could be obtained, it was established that in every case of fever which has occurred at Page Green the supply of drinking water had been wholly or in part, and in the immense majority wholly, from the surface wells. In 4 houses using local board water, and in which multiple cases of fever occurred it was ascertained that the inmates freely borrowed water from their neighbours' wells, and in the only 2 houses using the local board water in which a succession of fever cases took place well water was supplied from one of the wells mentioned in Col. 13.	In one row of 5 houses dependent upon 2 or 3 local surface wells, the inmates of all had been attacked by fever or diarrhœa, except in the case of one where the "family first boiled all the water which they used for drinking"	Report of Med. Officer, P.C.O. 1866.
5	Nov., 1865, to Apr., 1866	Buglawton, Cheshire	Dr. Buchanan, P.C.O.	150	14	1,150	—	—	—	Water supply of a particular portion of the village from a well "evidently habitually contaminated by drainage." Facts of the outbreak point to the specific pollution of the well water by typhoid poison derived from the first patient in the house adjacent to the well. Privies situate 30 paces from the well	Maximum attacks fell on a locality served by this well. Of 269 houses in the village, 75 were invaded, 150 persons being attacked. In the epidemic area in question, there were 56 houses, 29 being invaded, and 76 cases occurring. Analysis disclosed the fact that the well water, even after abatement of the disease, bore evidence of considerable organic contamination	Other waters used in the village probably of similar character; indeed, one other found so on analysis. The sewage polluted River Dane used for domestic purposes	Report of Med. Officer, P.C.O. 1866.
6	1865	Rural Parish, near St. Neots, Hunts	Dr. J. J. Evans	—	20	—	—	? All	—	Brook furnishing water to some farm cottages for all purposes running through a valley, and in its course of 3 miles receiving the drainage of 3 farmsteads, with house drain contents, as well as the land drainage of manured fields	The 20 deaths occurred in the parish through which the brook runs, and the majority originated in the farm cottages drinking the water of the polluted brook	The use of night soil becoming more general for manurial purposes, and fears of the consequences felt in regard of the water supplies	Brit. Med. Jour., vol. ii, 1866, p. 97.
7	Jan. to April, 1867	Winterton, Lincolnshire	Dr. R. Thorne Thorne, P.C.O.	55	6	1,800	—	—	—	Many wells in immediate vicinity of all manner of excremental filth, such as privy contents, slops, pigstyes, and the like	Instances given of association of fever with polluted wells. In one case of 4 cottages, 1 well supplying them had within a circuit of 14 feet an open drain, open ashpit, open cesspool. 2 pigstyes, and 3 privies, all, save the drain, being on higher ground and situate on a porous soil. Three of the 4 cottages invaded, the fourth escaping drew water from a neighbouring well	"The epidemic prevalence of fever in Winterton is undoubtedly to be ascribed to the disgraceful state of the privies, cesspools, ashpits, and wells. ......Given the existence of typhoid in a town, it is hardly possible to conceive conditions more favourable for its spread than those existing at Winterton"	Report of Med. Officer, P.C.O. 1867.
8	Aug. to Dec., 1867	Guildford, Surrey	Dr. Buchanan, P.C.O.	500	21	9,000	1,800	—	93 in epidemic fortnight	Houses in a certain part of the town exceptionally supplied on a particular day, and that day only, with water from a high-standing resevoir previously filled from a new well. This well sunk through a porous stratum of chalk and in close proximity to various sewers, one of which was found to leak in several places, almost certainly polluting the well	In the first fortnight of the epidemic, of 150 cases, all but a few ("less than a dozen") among consumers of the high-level service and even of the few exceptions, 3 shortly before attack "drank freely" of the water in question. Disease afterwards became more diffused, but during the whole period of the chief epidemicity, namely, in September, when 264 cases occurred, it was almost exclusively confined to the part of the town corresponding with the high-level section of the water supply. People of all classes were infected	Outside water "no other condition could be found, on careful and detailed inquiry, at all coincident with the outbreak of fever"	Report of Med. Officer, P.C.O. 1867; and Brit. Med. Jour., vol. ii, 1867, p. 454.
9	Dec., 1867, to March, 1868.	Terling, Essex	Dr. R. Thorne Thorne, P.C.O.	300	41	900	All	All	100	Wells everywhere of a shallow nature, and open to receive every possible pollution: "It is evident that for years the land springs supplying the village must have washed the foul materials which had soaked through the ground into the wells," though much diluted. Fever endemic in the village. A sudden great rise in the water levels after heavy frost and snow following drought showed undoubtedly that the wells had become the receptacles for the wash-	Disease commenced with a single attack (?imported infection) in mid-November. Fever suddenly epidemic in December; from 4th to 11th, 30 cases; from 15th to 17th, 53 fresh attacks. The whole village became infected. Of 145 cases whose ages are known, 79 were under 14 years of age (children being large water drinkers) and 50 females; the men being much from home and drinking beer. Numerous instances given of the intimate relation between polluted wells and localised groups of cases. Outside the village, among 71 persons procuring water from ponds, only 6 cases of fever, 4 being frequenters of the village, 3 of them scholars	As the epidemic progressed many adult males suffered from the fever, almost all having relatives ill, and being thus exposed to poisonous influences, atmospheric and other. Sudden rising of the water levels confined to Terling, the only village in the district invaded by fever	Brit. Med. Jour., vol. 1, 1868, pp. 14, 60, 102, etc.; Report of Med. Officer, P.C.O. 1867.

10	Sept., 1868, to Oct., 1869	Stamford	Mr. J. Netten Radcliffe, P.C.O.	132	?	8,420	4,459	79 of 97 cases inquired about	81.4 of above (col. 9)	Wells sunk in strata beneath the town in contiguity to cesspools. Latter pouring their abominations, by way of fissures, at a higher elevation than the water-bearing stratum of the neighbouring wells. "A subsoil in which the ordure of generations has been carefully stored up beneath the dwelling-houses, ... and drinking water laden with excremental refuse; these are the conditions which . . . . exist largely in Stamford." "There is not a well in the town which is not placed in dangerous proximity to sources of pollution"	Of 97 cases as to which facts were obtainable, 79 occurred among consumers of well waters in different parts of the town, 18 per 1,000 of persons drinking from wells; against 18, or 6 per 1,000, in persons using a public service. Of the former, 43 cases were among 857 persons drawing water from wells in 2 streets; 24 out of 30 cases occurring in 11 days of August, 1869, being among these same persons, and the well chiefly involved was found on analysis to contain water which was "simply sewage in a state of active putrefaction." In all, 37 out of 56 cases are known to have arisen in August and September among persons chiefly using wells in these two streets. In St. George's Square, one of the centres of chief prevalence, "it is no exaggeration of terms to say that the inhabitants of the north and east sides . . . . live upon soil which is saturated, breathe air which is tainted, and (so long as they use water from the pump in the square) drink water which is polluted with their own stools"	Mr. Radcliffe held it to be "probable that the difference in degree of prevalence of the disease in various parts of the town depended largely upon the state of humectation of the subsoil plus its excremental pollution"	Official report to the P.C.O.
11	Oct., 1868, to July, 1869	Eastbourne	Dr. R. Thorne Thorne, P.C.O.	100	15	10,000	—	All	100	1. Water supply of most invaded houses drawn from cistern which directly fed the closet. Odours arising from the cisterns much complained of. 2. Well sunk in alluvial soil, water being "strongly contaminated with drainage." 3. Private wells and other local sources giving unmistakable evidence of sewage contamination	Fever was prevalent in three divisions of the town, and chiefly affected houses having the water supplies severally named in Col. 11. A group of cottages supplied by No. 2 well especially affected. So also the population drinking from the No. 3 sources, which were open to all sorts of abominations, were heavily attacked	The passage of sewer air into the stagnant atmosphere of houses also an important factor in determining spread of the fever	Official report to the P.C.O.
12	Mar., 1869	Bramham College, near Tadcaster	Dr. Clifford Allbutt	19	1	60 or 70	All	All	100	Well water contaminated by sewage matter. A watercloset, into which the dejecta of 2 imported enteric cases had been cast, drained by a pipe over a soft-water tank, the contents of the pipe leaking out at a rat hole immediately over the water tank, which in turn was leaking on to the stonework of the adjacent well	This specifically polluted water furnished the college supply. All the cases occurred "at once" in late March, and nearly all of them were in total abstainers, and therefore, doubtless, large water drinkers, being, indeed, the chief, if not the only, abstainers in the establishment	—	Brit. Med. Jour., vol. 1, 1870, p. 309
13	Apl., 1869	Ackworth Moor Top, Yorks.	Dr. Clifford Allbutt	—	?	—	?	All	100	Well in village seriously contaminated by the infiltration of animal refuse. Water reached well by means of an excavated basin, near which were dwellings, foul privies, pigstyes, sumps, etc. Purposely polluted material emptied here experimentally quickly found its way to the water of the well. Initial case of fever traced, living in such a position that the dejecta buried where they were would certainly be carried by the winter rains to the stream supplying the well	An institution was involved in the outbreak, the place being carried on upon teetotal principles. Here and outside total abstainers were first and most largely attacked. Only one case occurred outside the area of use of the well, and that was of a boy who daily passed and often partook of the well water	Dr. Allbutt attended a case of fever in Leeds in a part where no other cases existed, and found the patient to have recently returned from Ackworth Moor Top	Brit. Med. Jour., vol. i. 1869, p. 452; vol. i, 1870, p. 309
14	April to Aug. 1869	Ingham, Lincs.	Mr. J. Netten Radcliffe, P.C.O.	53	2	646	—	All	100	Water supply in epidemic area from a pump well sunk in a porous soil, close to the churchyard, and open to pollution from various sources. Analysis proved the water to have received sewage contamination, and to be unfit for domestic use	Initial case in April in a house near the public pump in question. Forty-seven of the 53 cases in the same locality. Of 26 families grouped near the well, 8 not using the water escaped the disease; and of the remaining 18 only 1 escaped. Of the 7 cases in other localities, 2 are known to have drunk the water, and another presumably did so. Of 74 school children, 16 came from the fever area and several suffered; of the other 58 children, only the 2 who used the water were attacked. In one row the only families invaded were 3 who took to using the public pump before and during the outbreak	Two kinds of fever seem to have been in question, one unequivocal enteric, and the other continued fever. Not improbably independent, though contemporaneous, phenomena	Official report to the P.C.O.
15	July to Dec., 1869	Wicken Bonant, Essex	Sir Geo. Buchanan, P.C.O.	64	6	206	89	42 of first 45	94	Public well situate close to brook, the water in each rising and falling together in time of flood, and being alike turbid. Privy of house in which initial village attack occurred, almost on edge of brook, at a point 35 yards above the well. Case one of plentiful diarrhœa, the stools being cast into the privy without previous disinfection, and the well thus becoming specifically polluted by the medium of the brook	Fever imported from London, and by this means a villager infected, his evacuations being got rid of in the manner related in Column 11. Seven of the 8 inmates of this villager's household were attacked, and of 45 cases arising up to late November, 42 were among drinkers of the water of the public well, and only 1 positive case among 118 persons drawing water from private wells, the respective rates of attack being 46 and 3 per cent. of population. No difference between the two sets of residents, attacked and non-attacked, except source of water supply	As regards the later cases, the poison of typhoid would seem to have been "furnished from various sources," 9 being among persons using the public well, and 10 among those using private wells	Report of Med. Officer, P.C.O. 1869.
16	Aug. to Sept., 1869	Scothern, Lincs.	Mr. J. Netten Radcliffe, P.C.O.	16	4	579	All	All	100	Water supply from shallow wells universally exposed to pollution by reason of being sunk close to dwellings in a soil sodden with filth from imperfect drains and ill-constructed privies	No localisation of the fever, the conditions described being general in the village, so that "there are very few wells in the village of which the pollution may not be assumed"	Certain families very badly housed or much impoverished suffered to a greater extent than others	Official report to the P.C.O.
17	Sept. to Dec., 1869	Red Lane Estate, Coventry	Dr. R. Thorne Thorne, P.C.O.	142	16	1,180	All	All	100	Universal use of well water throughout the district, wells being sunk in close proximity to foul privies, middensteads, cesspools, and in soil saturated with the filth of years	Distinct evidence forthcoming, as the result of inquiry, of the relation as cause and effect of contaminated water and fever in each of the three divisions of the Red Lane Estate. As examples, of 9 houses served by a polluted well, 7 were invaded, 24 of the 53 residents suffering, 5 fatally; of other 5 cottages using a polluted well, all were invaded, 16 of 31 people being attacked; of other 4 cottages drinking water from a well to which drainage directly passed, all were invaded, 16 of 29 inmates being attacked	Disease frequently of a very severe character. The examples given in Column 12 of localised outbreaks round particular wells are indicative of the conditions generally obtaining	Brit. Med. Jour., vol. ii, 1869, p. 683; vol. i, 1870, pp. 18, 40, 116.
18	1869	Clifton Reynes, Newport Pagnell R.S.D.	Dr. R. Thorne Thorne, P.C.O.	"Very prevalent"	—	216	—	"Considerable number."	—	A species of cesspool within 3 feet of a well	A considerable number of the persons affected obtained their drinking water from this well	—	Official report to the P.C.O.
19	Jan. to Aug., 1870	Annesley, Notts.	Sir Geo. Buchanan, P.C.O.	100	6	400	All	All	100	People "drink their own excrement." Ground porous, permitting of ready absorption. A row of 40 privies with privy pits which "keep dry" by soakage of contents, and below these a well supplying the five blocks in which there has been most fever	All the ten blocks, and more than half of the 80 cottages, have been invaded. One end of the row suffered more than the other. Inquiry showed that the excrement of these cottagers had been "poured" into their drinking water. A well more distant from the privies than that just mentioned supplied the five blocks least heavily invaded	—	Official report to the P.C.O.
1	2	3	4	5	6	7	8	9	10	11	12	13	14

1	2	3	4	5	6	7	8	9	10	11	12	13	14
No.	Date of Outbreak.	Locality.	Reporter.	Total Number of Cases.	Deaths.	Population of Invaded Locality.	Number of Persons Supplied by Suspected Water.	Number of Cases amongst Drinkers of Suspected Water.	Percentage of Total Cases.	Exciting Cause of Outbreak.	Circumstances Implicating Water.	Observations.	Reference.
20	July, 1870	Rainford, Lancs.	Dr. C. I. Beard, P.C.O.	30 (about)	1	2,000	—	All	100	Brook, polluted by soakage from privy middens, dunghills, etc., "bears a close relation to most of the surface wells" in its vicinity. Water of both brook and wells at times "very offensive"	Fifteen cases of fever in a block of houses containing 35 people in July. Each house well built, and having a backyard reaching down to the brook. Evident means of pollution of brook by filth as above described, and well locally used subject to gross contamination. Well in cellar of a house; the slopstone pipes of adjacent houses have no external drain communications; bottom of well below the level of the brook 20 yards distant, and 30 inches below neighbouring ashpit midden of house where first case occurred. All the other cases of fever occurred in houses using wells polluted by neighbouring dunghills.	—	Official report to the P.C.O.
21	July, 1870	Ilkeston, Derbyshire	Dr. Buchanan, P.C.O.	?	3	10,000	—	—	Large	Drinking water from both public and private sources. Both have a great deal of excrement diffused in them. Two supplies "receive quantities of excrement," including enteric fever stools. One source is a coal pit in actual work, and therefore also liable to excremental pollution	People getting their water from sources that have received from elsewhere specific enteric fever poison have suffered to a very disproportionate degree	Enteric fever endemic in the town "for some time"	Official report to the P.C.O.
22	July to Sept., 1870	Bideford, Devon	Dr. R. Thorne Thorne, P.C.O.	?	11	6,000	—	—	—	Wells in numerous instances in close proximity to middensteads in a rotten and dilapidated condition, pouring their contents out on to the ground around. Pollution of wells such that people frequently refuse to use the water on their premises. Even public wells at times open to risk of contamination by means of adjacent privy middens and leaky old stone drains	Causes of fever "found to consist in an almost general excremental pollution of air, soil, and water." Examples given by Dr. Thorne, showing local outbreaks of fever in association with the use of obviously befouled well waters	—	Official report to the P.C.O.
23	Sept. to Dec., 1870	Radford, Notts.	Dr. R. Thorne Thorne, P.C.O.	300	26	9,000	—	—	—	Water supply from a well drawing water from an excrementally-polluted soil in the midst of a densely-populated district covered with privy middens and filth accumulations. Large sewage reservoirs also close at hand, leading to further pollution	Disease broke out epidemically towards the end of September, and was coincident with heavy rainfall after long drought, the pent-up sewage being thus carried to the water in a highly-concentrated state. Disease at first mainly on premises supplied by the well; analysis of water from which showed "probable contamination by sewage or surface drainage." In October the well was twice thoroughly cleansed, and at the end of the month abatement of the disease was observed	Epidemic was kept going by means of excremental contamination of air and soil, specific excremental matter being stored in ill-ventilated houses or cast into the streets or huge middens in dangerous proximity to dwellings. The year 1871 witnessed the continuance of fever prevalence, the last quarter's records pointing to from 300 to 400 attacks with about 50 deaths. Dr. R. Thorne Thorne reported on this second prevalence in February, 1872, associating it with defective house drainage and impure water service	Official report to the P.C.O.
24	1870	Appledore, Devon	Dr. R. Thorne Thorne, P.C.O.	150	11	2,500	—	—	—	Water partly from two surface wells in populous districts containing a "very suspicious sediment of light brown floating matter." One seriously fouled, having above and within 15 feet of it a refuse heap "containing a marked proportion of human excrement." Also many private wells so fouled as to have been disused, and still others in use "in such relation and proximity to sources of contamination that their contents must of necessity be polluted"	Sanitary condition of town deplorable, alike as regards water, sewage, and excrement disposal. Town "specially designed to favour outbreaks of typhoid fever." Conditions obtaining, as described in Column 11, associated with fever prevalence	—	Official report to the P.C.O.
25	Jan. to March, 1871	Coalville-Packington, Leicestershire	Dr. Home, P.C.O.	?	11	2,000	—	All	100	Wells in use, the water of which was unquestionably polluted by sewage	In one locality, inhabited by miners, every house was invaded, and 62 per cent. of the inmates suffered, all served by one contaminated well. Three weeks or so after the pump of this well was closed, the fever ceased. In another locality precisely the same cessation of fever followed upon locking up of the pump; but after an interval of some thirteen weeks, and about a week after the reopening of the pump, the disease broke out afresh	In the case of the well first mentioned in Column 12, of 44 houses and 273 persons served by it, every house was invaded, and 171 attacks resulted	Official report to the P.C.O.
26	Jan. to July, 1871	Hugglescote and Donnington Leicestershire	Dr. Home, P.C.O.	?	15	2,327	All	All	100	Wells, privies, pigstyes, and manure heaps crowded together. Enteric fever endemic. Subsoil of sandy loam, largely mixed with gravel. Water found at short distance from surface	Fever introduced in May, 1868, and spread by means of a specifically polluted well to adjoining houses. Disease present ever since, with intervals. Fever kept going by inter-relations of excrement disposal and wells, numerous definite instances being discovered of local wells spreading fever in large measure among the houses deriving their drinking supply from wells thus found to be open to excremental pollution. At Donnington some houses adjoining those invaded, but having wells carefully guarded against pollution, did not suffer	Intervals of freedom from fever thought of as having relation with dilution of the material of fever reaching the wells by excessive rainfall, lowness of wells and intense heat being regarded, on the other hand, as features favourable to re-	Official report to the P.C.O.

1	2	3	4	5	6	7	8	9	10	11	12	13	14
27	March ... July, 1871	Malpas,	Dr. Stevens, P.C.O.					All		from the works. Soon after a thaw set in; "the sewage-irrigated surface of the fields was thawed, and the inhabitants began to drink water just adulterated with the pent-up sewage of weeks," probably infected by "fever excrements"	water from the "town well" half way up a hill, but all apparently among persons obtaining their supply in the lower part of the village after conduction of the water through sewage-polluted meadows. Many cases in other townships, but all of them in children attending Malpas school, and drinking of its water as well as using its infected privy	the decomposing animal matter getting away being led to the source from which the water supply is obtained	P.C.O.
28	May to June, 1871	Burbage, Leicestershire	Dr. Gwynne Harries, P.C.O.	38	3	1,539	16 houses	All	100	A pump so situated as to be exposed to pollution from adjacent privy cesspit, the contents of which were known to soak away. Well water on analysis shown to be of consistency of water "mixed with more than half its bulk of average London sewage;" and fouling by excrement was proved. Privy believed to have been used by early fatal case of fever	Of 8 houses in the pumpyard, all drawing water from the pump were invaded, 18 cases resulting. Of other 8 houses in the town so supplied, all were invaded, and all the remaining patients had positively or presumably drunk of the well water. No person not drinking of this water was attacked. Every house using it was invaded	The fever was originally introduced at Christmastide of 1870, the sister of this case being the next to sicken in May following	Official report to the P.C.O.
29	June, 1871	(Not stated)	Dr. Norman Kerr	1+8 cases of diarrhœa	—	? 8	All	All	100	Well so situate that an old drain, which carried the liquid refuse from the pigstye and cattle-sheds, opened into it about 5 feet from the surface	Diarrhœa had not been absent from the farm for a fortnight prior to the development of the undoubted case of fever. By a method of exclusion the well water was suspected, and the unhealthy symptoms in the household changed from the day that a new water supply was brought in	Outlet of well built up, and drainage of yard diverted. Well afterwards reverted to without recurrence of illness in the household	Brit. Med. Jour., vol. ii, 1879, p. 337; vol. i, 1880, p. 88.
30	Aug. to Oct., 1871	Basingstoke	Dr. Ballard, L.G.B.	55+?	4 +?	5,574	All	All	100	Water supply and excrement disposal intimately associated. "Throughout the town people are unwittingly drinking their own excrement." Wells sunk in a cesspit-riddled soil. Soil water seen at times standing in cesspits. Soil loose gravel or chalk fissured in all directions	Fever not confined to any part of the town, nor to families of the poor. Places of its occurrence visited left no question of the dissemination of the fever poison by filthy emanations from cesspits, etc., and excremental pollution of water. Instances of fever spread by contaminated wells cited in report	—	Official report to the L.G.B.
31	Aug., 1871, to March, 1872	Leigh, Lancs.	Mr. W. H. Power, L.G.B.	200	35	11,355	—	All	100	Water from wells situated in backyards, near to privies and middens. Fever endemic in the town	Fever to a great extent localised, attacking as a rule the well-to-do operatives. In neighbourhoods invaded opportunity has largely existed for pollution of air and water by excrement. In one case, of 34 persons in one street using a polluted well, 17 suffered from fever; and of 12 houses in an adjoining street, 8 used the same well, and 7 were invaded, no cases occurring in the other houses drinking other water	—	Official report to the L.G.B.
32	Aug., 1871, to May, 1872	Whitchurch, Hants	Dr. R. Thorne Thorne, L.G.B.	70	6	1,450	All	All	100	Well of cottages first invaded open to pollution by adjacent privies, a heap of privy contents, and a ditch containing slops from the cottages. In the town generally the water supply and the disposal of excrement are "intimately connected"	First case imported, the fever spreading to the other cottage after a period of nearly four weeks, presumably by specifically polluted well water. Disease spread thence into various parts of Whitchurch, where the circumstances of water supply, of excrement disposal, and of drainage were favourable to its dissemination. Wells found to be polluted by "gas-tar," and, wherever tested, by much more serious matter, as slops, privy contents, and the like	The presence of gas tar was in itself indicative of the reception by the wells of "impurities from the surrounding soil"	Brit. Med. Jour., vol. ii, 1872, p. 225.
33	Autumn, 1871	Ilminster, Somerset	Dr. Blaxall, L.G.B.	Epidemic	12	2,800	—	—	—	Various water supplies; "analyses show that all contain more or less impurity of organic origin, in amount or quality indicating for all the water soakage from impure sources, and for some of them actually dangerous qualities"	"In Ilminster no special connection between the fever and any one water or soil could be made out, but indeed this was hardly to be expected in view of the general distribution both of fever and of foul conditions"	—	Official report to the L.G.B.
34	Oct., 1871, to Mar., 1872	Bayford Hill, Wincanton, Somerset	Dr. Home, L.G.B.	31	?	—	58	All	100	Reservoir water contaminated subsequently to its issue to a "horrible degree;" well placed in recess by roadside, quite unprotected, and higher ground within a yard of it, constantly polluted by wayfarers	Of 12 cottages containing 58 inmates, all were invaded, and 31 persons were attacked. All used the polluted reservoir water	The position, and foul, uncared-for state of the privies believed to have played a part in the fever prevalence	Official report to the L.G.B.
35	Oct. to Dec., 1871	Huddersfield Sub-District)	Sir Geo. Buchanan, L.G.B.	?	44	38,658	—	—	—	Spring in Northgate, supplying some of the residents, exposed to contamination from ground bored by old sewers and pitted by middens. Analysis proved the water to contain a considerable amount of sewage contamination	Inquiry respecting the distribution of fever in the borough showed exceptional mortality in and about Northgate, where the other circumstances favouring spread of the disease in the borough were by no means exceptionally present. Some cases met with of families which, being habitual drinkers of the particular water, suffered in the autumn under prolonged and severe diarrhœa, particular members being attacked by enteric fever, and this in houses where every requirement of health was presumably observed	—	Official report to the L.G.B.
36	Oct. to Dec., 1871	Fartown Green, Huddersfield	Sir Geo. Buchanan, L.G.B.	21	1?	84 houses involved	44 houses	20	95	Water from stream below where it received the drainage of farmyard littered with manure; the drainage of houses, manure heaps, and mill-scourings	Of 40 houses supplied from the public service, only one case of fever, and this in a house with a sink-drain in the sitting room. In the lane most affected, none of the houses, despite their filthy surroundings, taking the public supply had fever. Of the 44 served by the polluted stream 11 were invaded, 20 cases occurring	—	Official report to the L.G.B.
37	Jan. to March, 1872	Llanelly Subdistrict, Brecon	Dr. Gwynne Harries, L.G.B.	?	6	7,541	—	—	—	Water supply of extra-urban portion of the subdistrict (population, 3,333) from numerous streams, so situated as to be necessarily fouled by sewage. Analysis revealed that the water of one fountain was "to a great extent composed of sewage"	Fever shown, upon inquiry, to be closely related to local water supplies obviously polluted; whilst in the vicinity of a reputedly good water supply cases were far less numerous than in districts served by contaminated wells	—	Official report to the L.G.B.
38	Spring, 1872	Little Ash, South Molton R.S.D.	Dr. Home, L.G.B.	6	?	8 (two cottages)	All	All	100	Offensive cesspit draining to roadside channel passing within a foot of spring and cistern supplying the two households, the channel being nearly flush with the brim of the cistern	Cesspool close to the house where the first case (origin not traced) occurred. Six of the eight inmates afterwards suffered. Houses are isolated	This but one instance of spread of fever by polluted water service in Chittlehampton parish where were some 90 cases with 10 deaths during the autumn of 1870 to June, 1872. Excremental nuisances prevalent	Official report to the L.G.B.
39	March to June, 1872	Croyde, Devon	Dr. Home, L.G.B.	47	?	300	—	All	100	Water supply of the village exposed to risk of dangerous excremental pollution. Well situate near dungheaps and in close relation with dwellings	Imported case of fever started the epidemic which became generally diffused, attacking over one-third of the houses in the village, and spreading "through the medium of the discharges from the sick imparting specific qualities to the excremental filth with which the earth, air, and water of the place are universally and to an extreme degree befouled"	In three invaded houses the drainage from dungheaps flowed directly over the coverings of the wells	Official report to the L.G.B.

1	2	3	4	5	6	7	8	9	10	11	12	13	14
No.	Date of Outbreak.	Locality.	Reporter.	Total Number of Cases.	Deaths.	Population of Invaded Locality.	Number of Persons Supplied by Suspected Water.	Number of Cases amongst Drinkers of Suspected Water.	Percentage of Total Cases.	Exciting Cause of Outbreak.	Circumstances Implicating Water.	Observations.	Reference.
40	March to Aug., 1872	Ashton-in Makerfield, Lancs.	Mr. J. Netten Radcliffe, L.G.B.	?	17	7,463	—	All	100	Fouling of some of the open springs, shallow wells, and rainwater tanks in use	Fever spread not alone by impure water, but by this means in conjunction with defective drainage, methods of excrement disposal, etc.	Type of disease very fatal. In addition to the 17 fever deaths, 14 fatal cases of diarrhœa occurred, 13 in children under 5 years of age	Official report to the L.G.B.
41	May to Nov., 1872	Burton-Latimer, Northamptonshire	Dr. R. Thorne Thorne, L.G.B.	250	12	1,200	—	All	100	Wells supplying village so circumstanced that pollution can hardly be avoided from privy contents, slop water, and the like. Analysis of principal supply revealed indication of sewage or surface drainage contamination	First case occurred on premises where well is within 20 feet of hole into which refuse and slops are thrown. Instances met with of fever in association with wells open to pollution. Methods of excrement and refuse disposal and drainage such as to favour pollution of water and of air and to favour spread of disease. Heavy rains during epidemic period, such as would favour soakage of filth to the wells	—	Official report to the L.G.B.
42	June to Aug., 1872	Sutton-in-Ashfield, Notts.	Dr. Gwynne Harries, L.G.B.	?	?	7,581	—	—	—	Local water supplies from tanks and wells, specifically polluted by typhoidal matter by means of the first imported case at the top end of the town and another case following thereupon	After the first two cases the fever spread in the immediate neighbourhood, as many as seven patients being in one house; and every house in a particular yard was invaded in a space of two days, the common pump being in communication with a drain from an infected house. Corner house of adjoining street, using same well, also invaded. In another yard of eight houses and a street of ten new houses, drawing water from sources open to pollution from sewers and in other ways, there were 9 and 6 attacks respectively	Another locality invaded had under it the town sewage, which is there ponded when not required for mill purposes. All cases treated at home amid improper methods of excrement disposal and removal	Official report to the L.G.B.
43	June to Oct., 1872	Nunney, Somerset	Dr. Ballard, L.G.B.	76	?	832	800 (?)	All	100	Imported case of enteric fever, the evacuations being so deposited, together with those of others attacked in the same and adjoining houses, as to find their way into the brook whence the villagers derive their drinking water. Brook also specifically polluted at a later stage higher up still, giving rise to recrudescent fever	No fever cases, save one in February, for two years. From 8 to 13 fresh cases came under observation during five weeks following on heavy rainfall capable of washing the specific poison of typhoid into the brook. No authentic case of fever occurred in persons wholly using other water. Within a fortnight of good water being carted to the villages, the weekly cases fell to 5, and in the next week to 1	Actual excrement from typhoid patients was finding its way into the brook half a mile above Nunney as late as September. Early cases in the outbreak near to where the initial attack was housed traceable to the same cause as operated epidemically at a later period	Brit. Med. Jour., vol. i, 1880, p. 82.
44	July to Aug., 1872	Armley, near Leeds	Dr. Ballard, L.G.B.	107	11	9,224	Dairy farm well	—	38	Well sunk in porous soil, admitting sewage matter, and probably polluted by evacuations from a fever case on farm premises, excreta being cast in adjacent dungpit. Water used in dairying operations	Fever began to operate shortly after copious rains had rendered pollution of well imminent. Disease became epidemic suddenly and almost as suddenly abated a fortnight after the pump handle had been chained up, so far as customers of the dairy were concerned. In early weeks of prevalence all but one family drank milk from this dairy. Of families supplied therefrom 38 per cent. invaded; only 5.3 per cent. of invaded houses supplied by 18 other milk sellers, or not taking milk at all, suffered	—	Official report to the L.G.B.
45	July to Aug., 1872	Hucknall Torkard, Notts.	Dr. Gwynne Harries, L.G.B.	100	10	4,257	—	All	100	Immense rainfall in early July, washing the contents of privies and middens into the wells and streams whence the water supply is drawn. Enteric fever endemic	Fever suddenly epidemic, following on the rain storms. Middens and privies already infected by the evacuations of previous cases	The fever-infected population thus drinking fouled water, were also breathing impure air, and living in damp houses	Official report to the L.G.B.
46	July and later m'ths, 1872	Campden, Shipston-on-Stour R.S.D.	Dr. Gwynne Harries, L.G.B.	50 or 60	2	2,000	—	All	100	Well so situate as inevitably to suffer pollution from adjacent drains. Probably infected by discharges from initial case	Eight cases occurred in the house served by this well; and subsequently some 60 attacks were recorded among persons in the immediate vicinity, all drawing water from the same polluted soil and having imperfect drainage. No house escaped infection save such as had in previous recent years been invaded	All cases home treated	Official report to the L.G.B.
47	July to Dec., 1872	Hawkesbury Upton, Glos.	Dr. Ballard, L G.B.	113 to October	17	4,039	—	All	100	A case of fever imported into a cottage at the upper end of the village, the evacuations being thrown into the privy, thus specifically fouling the adjacent well	First families subsequently attacked used this well, a very large proportion being invaded. Infection spread to privy of national school, the well there becoming fouled; and school children carried the disease to villages and hamlets around, privies, and thereafter wells, becoming numerously infected, thus further spreading the disease	General infection of soil and privies probably contributed to spread, but in several instances where one privy served multiple houses, the only one invaded used the water of a particular well	Brit. Med. Jour., vol. i, 1880, p. 82
48	Aug., 1872	Boscolla, Truro R.S.D.	Dr. Blaxall, L G.B.	?	4	3 or 4 houses	All	All	100	Drinking water from a well contaminated by the percolation from a contiguous pigstye, and from a dungheap on which, in the absence of privy accommodation, excrement was cast	Local health officer connected outbreak with the use of water from this polluted well	—	Official report to the L.G.B.
49	Aug. to Dec., 1872	Wellington, Somerset	Dr. Blaxall, L.G.B.	180	19	3,825	All	All	100	Water supply from wells frequently liable to contamination from their situation near to privy pits and ill-constructed leaky drains	Fever prevalence chiefly located in three streets, in one of which an open drain receives filth from a privy-pit, pigstye, and manure yard, afterwards running near the wells whence drinking water is drawn, and in cottages near to which wells fever has been very rife. Water from these wells much complained of as regards unpleasant taste and discoloration	—	Official report to the L.G.B.
50	Sept. to Dec., 1872	Mendham, Suffolk	Dr. Airy, L.G.B.	45	5	544	—	—	—	Pump well close to cottage where first cases occurred; two privies with common cesspool ten yards away; also stagnant pool, receiving house slops. Water found, on analysis, to be contaminated by sewage	All the early sufferers either habitually or occasionally drank of the well water, which was doubtless specifically polluted by means of the slop-pool or privies	Fever later spread doubtless by other wells open to grave pollution from adjacent churchyard, and by other insanitary conditions prevailing	Official report to the L.G.B.
51	Oct. to Dec., 1872	Rotherham, Rawmarsh, and Greasborough, Yorkshire	Dr. Ballard, L.G.B.	?	83	39,832	All	All	100	Water supply from three sources, two of them exposed to sewage pollution, one being a well sunk in the town of Rotherham, and around which enteric fever had been present all the year, affording abundant means for specific fouling of the water. Gathering grounds of another supply manured by	Fever widely diffused, pointing to some widespread cause; invaded districts differently drained, but all supplied by the polluted water service. Rawmarsh, also in part supplied by same water, suffered as well, all the cases heard of occurring in persons so supplied; whilst in the adjoining village of Greasborough, drawing water from other sources, no fatal fever was recorded	Infected sewers in a particular vicinity thought of as contributing to spread of the disease	Official report to the L.G.B.

	to Jan., 1873	sall Heath, near Birmingham	L.G.B.					houses invaded		into the pervious ashpit privy doubtless found access to the adjacent wells, the water of one being used by a dairyman to dilute his milk on the one side, whilst a dairyman next door on the other side made no profession of selling his milk pure	number of other sellers, supplying families even in the same streets as those invaded, were free from fever amongst their customers	be found	P. C. O. & L. G. B.," No ii, 1874, p. 92. BRIT. MEDICAL JOUR., vol. ii, 1872, p. 719; vol. i, 1873, pp. 19, 68, 98.
53	Dec., 1872, to March, 1873	Bishop Stortford, Herts.	Dr. R. Thorne Thorne, L.G.B.	14	1	25 (4 cottages)	All	All	100	Well common to the four cottages so situated that pollution from leaky soil pipe of adjacent cesspool was inevitable. Evacuations of initial case thrown, untreated, down this soil pipe	Fourteen days after first case disease began to spread until all the houses had been invaded. A young woman from another locality acting as nurse also attacked, the disease spreading in like manner in her home similarly circumstanced	The above are only instances of association in Bishop Stortford of fever-spread and polluted wells	Official report to the L.G.B.
54	Dec., 1872, to Oct., 1873	Guisborough	Dr. Gwynne Harries, L.G.B.	200	?	5,202	—	All	100	Water supply until recently from shallow wells obviously exposed to pollution, and locally regarded as unwholesome. Wells scattered among houses and outbuildings. Methods of excrement disposal unsafe	An early case occurred in a house supplied by a well, probably infected, since some 15 cases of fever occurred in the vicinity in the previous year. Other five cases occurred in this house; not one case in 19 persons opposite supplied by a different well. This but an instance of facts revealed by investigation of prevalence which showed that the disease was closely associated with improper water supply and excrement disposal, wells being met with amid privies and refuse bins on crowded back premises	Cases treated at home	Official report to the L.G.B.
55	Jan. to May, 1873	Sherborne, Dorset	Dr. Blaxall, L.G.B.	243	13	6,041	4,680 (?)	226	93	Pollution of water supplied by local authority by infected air sucked into pipes from closet pans (enteric fever being present in the town) during intermissions of supply	Epidemic attacked almost exclusively persons drinking the town water. Sudden appearance of many cases early in March after nightly intermission of water service in February; diminution thereafter when intermissions ceased. During whole prevalence percentage of attacks on houses on town water service 29, against 7 on other services; and in epidemic period the rate was 14 against 3 per cent.	—	BRIT. MED. JOUR., vol. ii. 1874, p. 745
56	July and Aug., 1873	Marylebone and adjoining districts	Mr. J. Netten Radcliffe and Mr. W. H. Power, L.G.B.	244	26	—	760 families supplied by milkman	218	89	One of the farms supplying a London dairy company was situated in Buckinghamshire. Water for dairy purposes obtained from a well in a yard adjoining the farmhouse. On June 8th the occupier of the farm died suddenly of ambulant typhoid fever. Stools and chamber slops from this patient buried as a preventive measure in an ash-heap, but position of ash-heap such that its soakings must have found their way into the well used for dairy purposes. Heavy rainfall on June 29th probably assisted to wash the infected soakings more copiously into the well. Water used cold for cleaning dairy vessels, and simply as taken from well	All the cases occurred in the nine weeks ending August 30th, and within a circumscribed area. By far the greater number of families invaded were those of well-to-do people. Nine-tenths of the cases were in households consuming milk from a particular dairy. Wherever this milk was distributed, there the cases of enteric fever forming the outbreak were distributed. Where the milk supply stopped short, there, as a rule, the cases stopped also. The map of the distribution of the milk supply represented very closely the area of the outbreak. In certain localities where ramification of the milk supply extended, the cases occurring were, with one exception, among families using this milk. The disease picked out the streets to which the milk was distributed, and also the houses taking the milk	In regard of partial invasion of customers' houses. the implicated farm supplied only about one-sixth of the ordinary milk distributed by the dairy. It supplied, however, all the "nursery milk," which, when not wanted for its specific purpose, was mixed with the ordinary milk. In the early part of July, as the customers began to leave town, this "nursery milk," of which the same quantity was always sent to town, got to be more and more used for ordinary purposes. Inquiry tended to prove that the ordinary milk was infected only to such extent as "nursery milk" might have become mixed with it	Reports of Med. Officer. P.C.O. and L.G.B. No ii, 1874, pp. 103-136; BRIT. M. JOUR., vol. ii, 1873, pp. 206, 207, 296, etc.; *San. Rec.*, vol. ii, p. 390.
57	July, 1873, to Feb., 1874	Moulton, Brixworth R.S.D. (Northampton)	Dr. R. Thorne Thorne, L.G.B.	70	8	1,500	—	All	100	Wells sunk in a soil thoroughly fouled with excremental filth. Water undoubtedly polluted. Recent sewerage works revealed crevices in the rock in which the wells are sunk, filled with cesspool contents	**Fever associated with the use of well water unmistakably polluted by excrement**	—	Official report to the L.G.B.
58	July, 1873, to Nov., 1877	Ascot	Dr. Ballard, L.G.B.	69	—	—	100 families.	58	84	At the farm the milk cans were liable to befoulment even during process of cleansing, and water used for rinsing dangerous, being exposed to soakage of foul matters from privies and manure heap; and from absorption of the foul emanations from the drains which communicated with the pump case. No case of fever occurred at the farm till August, 1876, when the epidemic had lasted for three years. From this time onwards the water used for washing and rinsing the milk cans had an opportunity of specific pollution. Dr. Ballard could not account for the contagion reaching the farm, except that it had reached it in some way through the water entering the well in the yard. One of the cases of the great Marylebone epidemic of 1873 was nursed at the summit of the hill on which Ascot stands, and the evacuations were thrown carefully away, at a distance from the house, into a hole in the earth. The soil is a loose sand, and Dr. Ballard suggests that the specific matters thrown with the evacuations into the hole, in the very permeable sand, at a place not very far above the water layer, could, with the help of rain also running into the hole, have scarcely failed to reach the water layer beneath, and having reached it, would become more or less diffused in it; and, in the course of time, the movement of the mass of subsoil water might have brought it to the well at the farm	Of 3 milkmen supplying milk in the village, 31 per cent. of the customers of one were invaded, 6.5 per cent. of a second, and 1 of a third. Cases infected in the district, and using the implicated milk, were 50 as against 6 amongst persons not using that milk. In these latter cases the attacks could all be explained independently of the circumstances of a particular supply of milk having been drunk. [Epidemic only ceased when alterations were made in the drainage and pump of the farm]	—	BRIT. MED. JOUR., vol. i, 1880, p. 83. Report of Medical Officer of L.G.B. for 1877, p. 39.
1	2	3	4	5	6	7	8	9	10	11	12	13	14

1	2	3	4	5	6	7	8	9	10	11	12	13	14
No.	Date of Outbreak.	Locality.	Reporter.	Total Number of Cases.	Deaths.	Population of Invaded Locality.	Number of Persons Supplied by Suspected Water.	Number of Cases amongst Drinkers of Suspected Water.	Percentage of Total Cases.	Exciting Cause of Outbreak.	Circumstances Implicating Water.	Observations.	Reference.
59	Aug., 1873	Penstrase, Truro R.S.D.	Dr. Blaxall, L.G.B.	71	9	358	258	All	100	Water supply of invaded houses from an adit, subject to suspicion at its outlet, where is a dipping well liable not only to befoulment by dirty vessels, but also by excrement	Disease entirely limited to drinkers of the suspected water, 28 per cent. being attacked, whilst not one case occurred among the 160 users of other sources of supply	—	Official report to the L.G.B.
60	Aug., 1873	Wolverhampton	Dr. J. H. Love, M.O.H.	63	14	68,291	—	(See Col. 12)	—	Pump well of milk vendor's house within a few inches of an old flat-bottomed brick sewer which drained a locality where a number of cases of enteric fever had occurred. On August 11th, 1873, two of dairyman's children sickened of fever, and from this time the epidemic began to spread markedly in other quarters of the town	The disease followed the course of the milk supply. Of 18 cases on the list of one practitioner, 15 were supplied with this milk. Majority of persons attacked well off, and living in good houses. [Epidemic stayed by cutting off the supply of pump water used by the milkman]	—	Brit. Med. Jour., vol. ii, 1873, pp. 267, 292, 334, 447.
61	Sep., 1873, to Apl., 1874	Baldock (Herts)	Dr. R. Thorne Thorne, L.G.B.	60	3	2,000	—	All	100	Water supply from wells in chalk, obviously polluted by the soakage from cesspools, refuse heaps, imperfect drains, and the like. Outbreak of fever coincident with the construction of new sewers and consequent disturbance of the polluted strata through which the water flows to the wells	Careful investigation showed that the disease was associated with the use of polluted water. Spread favoured by numerous accummulations of house refuse, sewer emanations, and overcrowding	No hospital or means of disinfection being available, patients were treated at home	Official report to the L.G.B.
62	Nov., 1873	Maidford (North Hants)	Mr. A. Haviland, M.O.H.	20 families	*nil*	363	—	All	100	Village quadrangular in form, the centre of the square occupied alike by wells, manure heaps, pigstyes, etc. Surface drains imperfect, and the wells all more or less polluted by sewage. Town well so polluted, having an old cesspool within a few feet of it. Strata on which village lies of porous nature, the water being drawn from above the clay	The fever mainly (and *all* the earlier cases) in the lowest lying houses, having wells grossly polluted. The wells so situate as to be exposed to the adventitious soakage of drains and cesspits, some of which also empty into the brook bordering the lower part of the village. Cause of the epidemic believed to be entirely resident in the water.	Of over a dozen wells examined, only one found not to be polluted by sewage	Brit. Med. Jour., vol. ii, 1873, p. 671.
63	Nov. to Dec., 1873	Caius College, Cambridge	Sir Geo. Buchanan, L.G.B.	15	—	112	—	All	100	Contamination of a particular section of the college water service, during a period of intermission, by the entrance into it of air charged with the contagium of enteric fever	Epidemic mainly confined to a particular court, in which it affected all the levels and staircases. It began a fortnight after the intermission of supply. Watercloset air shown to have had direct communication with the waterpipes	—	Brit. Med. Jour., vol. ii, 1873, pp. 671, 696; vol. i, 1874, pp. 51, 116, 211, 843; vol. i, 1880, p. 82.
64	Dec., 1873	Tregoney, Truro R.S.D.	Dr. Blaxall, L.G.B.	50 or 60	5 or 6	745	?	? All	? 100	Public well water found on analysis to be highly polluted and unfit for domestic use	Fever "so prevalent" among users of the "public well" as to lead health officer to obtain the analysis which condemned the supply	Spread of fever also doubtless due to methods of excrement disposal about houses	Official report to the L.G.B.
65	1873	Stone Sub-District, Staffs.	Dr. Ballard, L.G B.	180 (estimated)	13	10,088	All	All	100	Wells sunk in a porous soil, often close to privy cesspits, and usually of necessity excrementally polluted	Observations left no doubt of the fact that the fever was spread in great part, if not entirely, through the medium of privies and wells infected with the excremental discharges of the sick	—	Official report to the L.G.B.
66	April, 1874, to Oct., 1875	Bristol Lunatic Asylum	Dr. G. Thompson, Medical Superintendent	23	—	—	All	All	100	Water drawn in part, at times, from a well sunk in highly fissured rock between the river Froom and the asylum drain, the latter discharging to an old quarry hard by. River received the sewage of an adjacent workhouse, with its thousand inmates; and the asylum well water proved on analysis in 1871 to be "little better than sewage."	This well water used in 1874 from March 23rd to 30th. There were two cases of fever on April 28th. Water again used from May 28th to September 9th. From July 9th to October 13th, there were 15 cases. Water also used in 1875 for 42 days prior to July 15th, and from August 27th to October 21st. In July 4 cases of fever arose, and in October 2 cases	This diluted sewage used with impunity in the absence of fever cases, from 1864 to 1873. In the latter year Dr. Thompson regards 5 cases as due to its consumption, following on a case arising in the asylum from polluted milk; the dejecta having presumably been cast down the asylum drains	Brit. Med. Jour., vol. ii, 1879, p. 795.
67	June, 1874	Taunton, Somerset	Dr. H. J. Alford, M.O.H.	5	—	15,466	?	5	100	Well water of dairy "fearfully contaminated" with sewage, and smell very offensive. Well saturated with sewage, which was clinging to the bricks where it had trickled down	Sanitary circumstances of invaded houses good. In one house all the inmates but one drank milk from another dairy; but the one who suffered from fever drank this particular milk	—	—
68	June to Oct., 1874	Bourton-on-the-Water, Gloucestershire	Dr. Ballard, L.G.B.	137	4	1,109	All	All	100	Evacuations of a typhoid patient cast into a privy overhanging a stream supplying drinking water to many of the villagers lower down. Wells generally in dangerous proximity to privies and drains	First cases among persons drinking water from this brook and from a well with which the brook communicated. Epidemic subsequently caused by specific pollution of local wells by excremental matters from cesspools and drains into which the evacuations of fever patients had been emptied, and by soakage from the brook	—	Official report to the L.G.B.
69	July to Aug., 1874	Peterville, Truro R.S.D.	Dr. Blaxall, L.G.B.	?	8 or 9	—	?	Most	Large	Water supply from a well 20 feet below five cesspits, into one of which the evacuations of an earlier fever case had been habitually emptied. Water drawn from direction of cesspits, and found on analysis to be seriously polluted	Fever largely among consumers of polluted well, some being miners living at a distance but using the well water while at work in Peterville	—	Official report to the L.G.B.
70	Aug., 1874	Queensbury	Dr. Britton, M.O.H.	36 in 24 houses	1	6,012	—	34	94	Well very close to house drain, roughly made of stone. Earth between drain and well found saturated with sewage. Well loosely made, so as readily to admit of percolation. Farmer's wife	Drainage and water supply of infected locality fairly good. All the cases but two were supplied with milk from farm [On drain being removed, and well cleaned out, fever stopped, and there was no return of it]	—	Annual report of Med. Officer of Health for 1874.

71	Aug. to	Lewes	Dr. R. Thorne, L.G.B.	496	37	10,753	5,000	32 at end of Oct.	80	Pollution of … Lewes, by the river Ouse, into which the sewage of Lewes is poured. Stream so used a fortnight prior to outbreak under tidal conditions which especially lent themselves to secure entry of sewage-polluted water to the inlet pipe, the tidal valve of which had been left open as the action of some children	6 of them single cases in the only drinkers of the water in their homes, to which other water was laid on. Of 412 cases in the epidemic period, 325 were in houses drawing from the public service; others probably, and some certainly, in reality drank the town water. In one district with 454 houses, 60 have town water laid on; 16 cases of fever occurred, 15 certainly being in persons drinking the water	ber, probably by the opportunity afforded for insuction of sewer air and excreta by direct connection between closet pans and water mains, this, too, in houses having early cases of fever, and with an intermittent service. Such insuction demonstrated. Outbreak in prison attributed to sewer gas. Sewers in places intersected by faulty water mains and lead service pipes	JOUR., vol. ii, 1874. p. 687; vol. i, 1875, pp. 135, 197, 285, 386, 420.
72	Aug. to Dec., 1874	Lower Gornall, Staffs.	Dr. Ballard, L.G.B.	700	34	6,147	—	All	100	Water supply from wells polluted by excremental matters, and from "springs," which could not fail to have received the specific poison of enteric fever	Fever traced to the use of certain specifically-polluted wells and "springs," fever cases having occurred in former years and earlier in 1874, and been treated at home in the absence of proper drainage. In one row of 21 houses drawing water from a well subject to privy soakage, 20 houses invaded. Privies contained evacuations of fever cases. In Summer Lane, partly deriving water from a source open to receive soakage from a privy at house invaded early, 40 cases occurred. The prevalence of the disease was especially severe in other parts of the town procuring water from sewage-polluted sources	Fever doubtless, to a less degree, spread by the medium of infected privies	Official report to the L.G.B.
73	Sept. and Oct., 1874	Hull	Dr. King, M.O.H.	526 + ?	?	121,892	All	All	100	Water supply intermittent, especially so about the date of the outbreak. Attention of Dr. King drawn to the continuous stream of air which was forced out of the water pipes when some of the taps were opened. At times also this expelled air was offensive, and complaints were made of evil smell of the water as it issued from the mains	Dr. King fully satisfied himself that air had, during intermissions of water service, been drawn into the mains which in their course through the streets lie close to the sewers. There was every reason for belief that foul air, if not other foul matters, had facilities for entering the water pipes. The outbreak was inexplicable on other grounds than some such pollution of water mains	The 526 cases mentioned in Col. 5 were attended by 4 out of the 50 or 60 medical practitioners in Hull. Actual epidemic probably therefore of much greater magnitude than here stated	BRIT. MED. JOUR., vol. i. 1875, p. 51
74	Oct. and Nov., 1874	Dundee	Dr. G. C. Pirie, M.O.H.	19	4	—	—	19	100	Well at farm used for all domestic purposes, and for washing milk vessels and utensils, had near it two dungheaps where fæcal evacuations of sick were deposited. Water reported by Dr. Stevenson Macadam to be "contaminated with the products of decomposing organic matter of the nature of sewage." Four cases of typhoid fever at the farm	All the cases supplied by particular dairy. Cases all occurred within a period of six weeks, although before that period typhoid was very sparingly, if at all, observed in that district	The bedroom occupied by all 4 patients at the farm during their illness was on ground floor. Opening from this apartment was the milk store—subsequently moved outside house	BRIT. MED. JOUR., vol. i, 1875, p. 225
75	Oct. to Dec., 1874	Over Darwen	Dr. Stevens, L.G.B.	2,035	110	21,273	All	All	100	Pollution of water conduit supplying Over Darwen, with the specific poison of typhoid. Excreta from imported case carried by a watercloset drain of defective construction and choked condition, and the contents of which had found exit from the drain and entrance to the water conduit though faults in imperfectly secured joints, as was afterwards demonstrated	Outbreak sudden and universal, some 1,500 cases being under treatment within a space of three weeks. Water supply the only condition common to the whole town, the epidemic affecting all classes of dwellings, all parts of the town, and variously circumstanced as to local filth conditions.	A like epidemic prevailed in 1861, causing 70 deaths, and due to somewhat similar pollution of the town water service.	BRIT. MED. JOUR., vol. ii, 1874, pp. 563, 592, 823; vol. i, 1875, p. 53.
76	Jan. to March, 1875	Crosshill and Eaglesham, Scotland	Dr. E. Duncan	280	?	14,000	262 families	94 families	36 families	Enteric fever occurred at a farm in November, 1874, the drainage from a dungstead on this farm flowing towards two wells used by the farm and by the residents in an adjacent row of houses. Fever invaded these houses in December. The stools of at least 20 patients were cast into the privies, soakage from these privies, and from the dungstead just named, finding its way into a neighbouring streamlet which formed the water supply of another dairy	The outburst did not take place until January, and it is a fact that at the date of the occurrence of fever in the house spoken of in Col. 11, the privy contents were frozen up for some five weeks, when a thaw set in with rain, and the accumulated contents of the specifically infected privies drained towards the streamlet. Among the consumers of the milk from the farm invaded in November and the farm using this streamlet it was that the special incidence of the fever occurred. Of 262 families using the milk, 94 were invaded; and only 18 out of other 242 families taking different milk, and of these 18 there were 10 families who occasionally drank milk from these farms	It was matter of surprise that only 18 (or most probably 8) families were invaded elsewise than by the implicated milk, looking to the large area covered by the epidemic	BRIT. MED. JOUR., vol. i, 1875, p. 354; vol. ii, 1875, p. 61.
77	Feb. and March, 1875	Crosshill, co. Renfrew	Dr. H. D. Littlejohn and Dr. E. Duncan	153	—	—	—	94 out of 112 invaded house holds	84 (of house holds)	Water supply derived from well in close proximity to byre, and to a large collection of liquid manure from which much refuse escaped. Well furnished by supplementary supply of water from spring dangerously exposed to pollution from a ditch. Analysis showed water to be decidedly impure. Typhoid fever was very prevalent in village (Eaglesham), where farm was situated, and 2 of the farm children had suffered from the disease. Their discharges were thrown either on the manure heap or into the ditch. Their attendants superintended the arrangements for the collection and disposal of the milk; and the connection between dairy and rest of house was free and open. Disease subsequently broke out in house of one of the retailers of the Eaglesham milk at Crosshill	Of 504 houses, disease appeared in 112, 94 (or 84 per cent.) of which were supplied, wholly or partially, with milk from Eaglesham. No dairyman who drew his milk from Eaglesham escaped having disease amongst his customers; while there were 7 dairymen (in addition to others having a few cases, though not supplied from Eaglesham) who had their milk supply from other districts, and had no disease amongst their customers at all. At Langside, a village quite distinct from Crosshill as regards its drainage, fever appeared in 6 of the 46 villa residences, attacking 16 persons but completely sparing the village proper. Of these 6 villas 5 were supplied with milk from Eaglesham. Forty other villas, and the rest of the village supplied by local dealers, escaped entirely.	House adjoined the shop, with which there was free communication, this doubtless giving an impetus to the dissemination of the poison	"Official report to Board of Supervision." BRIT. MED. JNL., vol. i, 1875, p. 391. *San. Rec.*, vol. ii, 1875, p. 61.
78	April to Sept., 1875	Chatteris	Mr. J. Netten Radcliffe, L.G.B.	—	12	4,749	All	All	100	Privies and ashpits in contiguity to shallow wells sunk in a porous stratum of gravelly soil. Local conditions of excrement disposal permitted of soakage of foul matters to the water of the wells	Detailed inspection of the district revealed that the prevalence of fever was mainly dependent on the existing conditions of excremental disposal and water supply	—	Official report to the L.G.B.
1	2	3	4	5	6	7	8	9	10	11	12	13	14

1	2	3	4	5	6	7	8	9	10	11	12	13	14
No.	Date of Outbreak.	Locality.	Reporter.	Total Number of Cases.	Deaths.	Population of Invaded Locality.	Number of Persons Supplied by Suspected Water.	Number of Cases amongst Drinkers of Suspected Water.	Percentage of Total Cases.	Exciting Cause of Outbreak.	Circumstances Implicating Water.	Observations.	Reference.
79	June to July, 1875	Müller's Orphan Asylum, Bristol	Dr. D. Davies	500	12	2,000 in 5 houses	Col. 12	Primary cases	—	—	Children, during course of their regular walks, permitted to drink from a stream in a neighbouring dingle, the stream being fed by sewage from houses, in some of which enteric fever had recently prevailed. Thirty cases broke out simultaneously among children having thus had opportunity of drinking specifically infected water	Fever kept going inside the establishment when once introduced	*Sanitary Record*, vol. iii, 1875, p. 95.
80	Sept., 1875	Jarrow	Mr. John Spear, M.O.H.	25	—	—	27 families	14 families	? 100 of cases	Well water used in the implicated dairy found to be grossly polluted by sewage. Eighteen yards from the well were a privy and cesspit. the latter a mere hole. Six cases of fever in this farm	No less than 14 families using milk from this farm were invaded, 25 cases occurring. Polluted water supply cut off, and epidemic ceased	The attendant on the sick at the farm also milked the cows, and infected clothing was actually washed in the dairy itself, which moreover communicated with the sick room	**Brit. Med. Jour.**, vol. ii, 1875, p. 372
81	Autumn, 1875	Melbourne, Royston R.S.D., Herts	Dr. R. Thorne Thorne, L.G.B.	13	2	1,759	11 houses	6 houses	54	Well so circumstanced that its contents can hardly have failed to have become poisoned by the excreta of a typhoid patient	Of 11 houses using the well, 1 rarely tenanted, 1 previously invaded, 1 occupied by an old woman only; 6 of the remaining 8 invaded, with 13 cases	—	Official report to the L.G.B.
82	Sept. to Dec., 1875	Gunnislake, Cornwall	Dr. Blaxall, L.G.B.	143	8	3,000	1,916	138	97	Evacuations from two fever cases, one being imported, thrown on a dustheap, near to an adit feeding the reservoir containing the implicated water. Soil porous, gradient steep, and rainfall excessive just prior to general outburst; all these favouring specific contamination of the adit, and by this means of the reservoir contents, the water supply being subjected thus to pollution by means of the bowel discharges of each of the two fever cases at intervals of six weeks	Outbreak sudden in mid-October, confined to area of reservoir service. Of 1,916 persons taking the water, 138 attacked, 72.0 per 1,000; of 1,085 persons having other and various waters, only 5 attacked, 4.7 per 1,000 All these 5 probably partook at times of the reservoir service. Six of the water drinkers worked or visited only in the area of supply, residing elsewhere	—	Official report to the L.G.B.
83	Oct. to end of 1875	Dundee	Dr. G. C. Pirie, M.O.H.	19	4	—	?	All	100	Well of dairy farm found on analysis to contain water contaminated with sewage. Cases of fever at the farm in August. The soil around the well fouled by soakage from adjacent dungheaps. Fæcal evacuations of the sick cast on these dungheaps, and doubtless carried by percolation to the well	All the persons attacked were consumers of milk from this farm, milk supply being the only community of condition. All classes attacked	Well immediately closed on attention being called to its polluted state	**Brit. Med. Jour.**, vol. i, 1875, p. 225.
84	Dec., 1875	Heolfach, Rhondda Valley.	Dr. Airy, L.G.B.	150	5	—	—	—	—	Probable pollution of local water spout by the specific poison of enteric fever from a privy on porous soil, and at a higher level 20 yards away	An enteric fever patient had constantly frequented the inn to which the privy is attached, and which is open to all passers by; and 13 persons were attacked on or about Christmas Day out of 131 occupying 20 houses, all drinking the suspected water. Local rainfall such as to favour theory of soakage of excreta to the water as causative of the outburst	Other 28 persons in these 20 houses attacked later, only 3 of the houses escaping. Details as to precise methods of further large spread of fever not obtained	Official report to the L.G.B.
85	Jan. to Feb., 1876	Eagley and Bolton	Mr. W. H. Power, L.G.B.	339	21	?	577	301	90	Fouling of brook used for all dairy purposes at a farm the milk from which caused the fever outbreak. Fouling consisted of the evacuations of workmen, there being "abundant evidence that some individual who had used the stream (banks and bed for purposes of defæcation) had suffered from diarrhœa," suspiciously typhoidal in character. Analysis of the water pointed to excremental pollution	Of 57 families in Eagley supplied by the farm, 55 (96 per cent.) were invaded by fever; of 8 invaded families outside the farm supply, 6 had occasionally partaken of the milk in question. In Bolton outbreak coincident in time with that at Eagley, and in every house to which the same farm supplied milk, cases of fever occurred, to the number of 106. Of the total number of persons in households taking the milk, 52 per cent. were attacked	Secondary cases occurred to the number of nearly 40, in houses already invaded. The brook yielding water to the dairy had been abandoned by other households using it prior to the outbreak, on account of its obvious defilement	**Brit. Med. Jour.**, vol. i, 1876, pp. 201, 233, 273, 293, 494
86	Mar. to May, 1876	Tideswell, Bakewell R.S.D. Derbyshire	Dr. R. Thorne Thorne, L.G.B	16	7	1,905	—	10	62	Pollution of a small water main by insuction of specifically fouled air by means of an open tap leading from a closet pan into which the excreta of two early typhoid patients had been cast	All the earlier cases occurred in a limited portion of the village among persons drinking water from the small main in question	The excreta from the first patient led to pollution of the sewer-brook at a point where it had a small flow of water and was arched over, so that houses draining to it were exposed to communication of infected air by means of sink pipes; this probably being a factor in the spread of the fever	**Brit. Med. Jour.**, vol. i, 1877, p. 185.
87	Summer, 1876	A village, near Leeds	Dr. R. P. Oglesby	4	nil	10, one household	All	4	40	Watercloset drained to a running stream close by the house, and which became "mere sewage." This contaminated water was the only drink the one milch-cow could get	Cow had been ailing for the past three or four months during which the cases had been lingering on in the house, the animal "getting thinner, and refusing to graze." Milk furnished just sufficed at last for household purposes, and creamed badly. After the cow was sent away, and milk obtained elsewhere, complete though tardy convalescence resulted	One prominent symptom of the earlier illnesses was convalescence during the use of the milk "by fits and starts;" one day cheerfulness and playfulness of the children; another day lassitude and a desire to rest	**Brit. Med. Jour.**, vol. i, 1880, p. 89.
							All	All	100	Water supply derived from a stream	The disease occurred in houses remote one from another, and having	—	**Brit. Med. Jour.**, vol.

89	Au-	Churwell	Dr. J. C.	A number	9	—	—	—		found on analysis to be altogether unfit for drinking purposes. (Farmer denied having used well water for dairy purposes.)	Morley. Out of 25 to 30 cases occurring at the latter place, all, with one exception, drank milk from the farm. Many of the houses were healthy; some were new, with good drainage and water supply	polluted water	
90	Nov., 1876	Great Coggeshall	Dr. R. Thorne Thorne, L.G.B.	28	—	3,454	—	28	100	Water taken for purposes of dairy from a polluted brook, only a few yards from where a drain emptied into it. A young woman came home from London with what turned out to be typhoid. The slop water (including the swillings of bed linen saturated with the patient's bowel discharges) were poured, without disinfection, into a drain emptying into the brook already referred to	Nothing common to the persons attacked, except their milk supply. There were four milk vendors in the town, but only the customers of the particular dairy were attacked	—	Official report to the L.G.B.
91	Nov., 1876	Linlithgow Bridge, Scotland	Dr. Littlejohn	62	7	465	All	All	100	Wells supplying the village with water in a polluted state	Dr. Littlejohn held the disease to have been primarily caused by the use of polluted well water, and to have been afterwards epidemically spread by milk from infected farms	Methods of disposal of infective excreta also doubtless largely contributed to spread of the disease	BRIT. MED. JOUR., vol. ii, 1876, pp. 663, 692, 727, 802
92	Dec., 1876	Salford	Dr. J. Tatham, M.O.H.	13	—	124,801	—	13	100	One of the five farms from which a Salford retail dealer drew his supply situated on very porous and sandy soil favouring percolation. Surface drainage very imperfect. Well close to privy-cesspool, and a yard or so off a sink for dirty water. Typhoid had been epidemic at this farm for a long period, 16 cases occurring within 20 years	Cases occurred almost simultaneously in houses inhabited by well to do people. Drainage and water supply of houses perfect, and no intercommunication between the families. Milk supply, with scarcely an exception, from the same retail dealer. (Supply discontinued, and no further cases occurred.)	—	Annual Report of Medical Officer of Health for Salford, 1875-1876.
93	Dec., 1876, to Feb., 1877	Stapleford, Derbyshire	Dr. R. Thorne Thorne, L.G.B.	15	—	2,600	—	—	—	Water supply of village from wells either obviously foul, or subject to constant risk of pollution from heaps of refuse, large leaky midden-privies, and the soakage of slop water. One brooklet, the "Sick Ditch," polluted by the sewage of a group of houses just above and of 30 houses just below the dipping place and water taken for drinking purposes still lower down. Enteric fever cases in two houses discharging sewage to the stream	Enteric fever prevailed among users of the "Sick Ditch" water, and was notably prevalent also amongst consumers of a well in Mellows Yard	In the five years 1872 76 there were 13 deaths from enteric fever in the village, the sanitary condition of which was such that, given the existence of the disease, infection was almost certain to spread	Official report to the L.G.B.
94	Jan. to Mar., 1877	Dewsbury, Batley, Heckmondwike, and Ravensthorpe (Yorkshire)	Dr. R. Thorne Thorne, L.G.B.	About 600	58	67,656	All	All	100	One water supply common to all four districts, and one of the streams feeding the subsidence reservoir found to receive drainage from a farm house and its stables, cowhouses, etc. Gathering ground subject to pollution of various kinds, such as manure spread on the fields; whilst the conduit was liable to contamination of different kinds in its course to the reservoir. Specific infection of the joint supply at its source held to be the cause of the epidemic, no other explanation being possible	Water supply the only feature common to the invaded districts. Mortality from fever in this epidemic area 17 times that of the remaining ten urban districts in the same registration area. The epidemic, moreover, commenced simultaneously in all the four districts, though each has a separate delivery main. Inquiry too long after the occurrence to make the fact of specific infection of water absolute. But enteric fever was at first confined to persons drinking the water, and before other factors of spread came into operation, such as defects of sewerage, drainage, and excrement disposal. Intermittency of supply also conduced to spread by insuction of tainted air and the contents of leaky sewers into the water mains	—	Official report to the L.G.B.
95	March. 1877	St. Pancras and Islington	Dr. Stevenson	34	?	—	—	29	85	Milk pails washed at a farm with water from a pond liable to contamination	When 14 cases had occurred, quite suddenly and after entire absence of the disease, only 1 attack could be discovered in the area served by the particular milk dealer in a person not drinking his milk. Of the 34 cases occurring in all, 29 obtained milk from this one milk dealer, who had his supplies from three different farms. At two of these impure water was found in use for dairy purposes	—	BRIT. MED. JOUR., vol. i, 1877, pp. 275, 359.
96	April to July, 1877	Bradford, Wilts	Dr. R. Thorne Thorne, L.G.B.	50 to 60	8	7,000	—	Nearly all	—	Case of fever at a house called "Chantry," under which flowed springs which could not escape pollution by the contents of the waterclosets belonging to "Chantry" in their soakage from an old stone sewer	Springs flowing under "Chantry" supplied two houses and a public tap, to which children from a neighbouring school resorted. Twenty children residing in different parts of the town, but attending this school, were attacked by fever, other cases occurred in persons using the tap, and in the private houses to which the water was laid on. South of the river the only cases were in schoolgoers, and closing of the tap was followed by cessation of the epidemic among the school children	Water supply of town derived from springs cropping out of the oolite, the water being procured from wells or reservoirs constructed in the fissured rock, and long subject to penetrated filth. A disturbance of the soil of the town for purposes of sewerage helped the epidemic apart from the school	Official report to the L.G.B.
97	July to Aug., 1877	Bedale, Yorkshire	Mr. W.H. Power, L.G.B.	36 (20 families)	5	1,000	—	15 families invaded	75	Case of fever introduced to a house where all the conditions conducive to spread of the disease existed—for example, polluted water, bad drainage, insanitary methods of excrement disposal	Fifteen of 20 families invaded partook of water from one well, in the trough of the pump of which well all kinds of foul matters were washed, such as tools and barrows used in the emptying of privies. The slop drain of the pump, close to if not over the well, constantly becoming choked, with resulting pollution of the well by the waste-water soakage	The sanitary state of Bedale such that only the introduction of the specific poison of enteric fever was needed to cause spread of the disease; all wells being sunk in a porous water bearing soil subject to excremental pollution	Official report to the L.G.B.
98	Jan. to March, 1878	Moss-Side, near Manchester	Dr. E. Sutcliffe, M.O H.	32	3	5,311	—	29	90	Two deaths from typhoid occurred at farm in February. Water of farm, whence came part of supply of dealer, derived from well in close contiguity to ashpits. This water found on analysis to be polluted from sewage contamination	Of a total of 32 cases, 29 occurred in houses receiving their milk supply from the same dealer. The particular dealer supplied milk from his own establishment, and from a farm eighteen miles distant. Those supplied regularly from farm principally attacked. Houses in infected district supplied by other dealers enjoyed a remarkable immunity. Amongst 214 houses supplied from one of the principal dairies in only one did disease make its appearance; and in this case the inmates had held direct communication with one of the houses already infected	—	*Medical Times and Gazette*, vol. i, 1878, p. 517.
1	2	3	4	5	6	7	8	9	10	11	12	13	14

1	2	3	4	5	6	7	8	9	10	11	12	13	14
No.	Date of Outbreak.	Locality.	Reporter.	Total Number of Cases.	Deaths.	Population of Invaded Locality.	Number of Persons Supplied by Suspected Water.	Number of Cases amongst Drinkers of Suspected Water.	Percentage of Total Cases.	Exciting Cause of Outbreak.	Circumstances Implicating Water.	Observations.	Reference.
99	July and Aug., 1878	Bristol	Dr. B. Davies M.O.H.	131	12	182,696	—	131	100	Closets used by dairy farmer's family discharged by a common drain into a cesspool, situated 25 feet from the well. The cesspool was overflowing in all directions, and its contents were traced by a recurrent course distinctly into the well. Manure of all kinds, and in every stage of decomposition, lay about everywhere. The well water was the only water for domestic use on the farm. In June, a young lady, convalescing of typhoid fever, spent some time at the farm for change of air. Her evacuations (no doubt still infectious) passed into the common privy	The outbreak was strictly confined to persons who drank milk from this farm, these persons being the customers of several retailers, all of whom, without exception, were supplied either directly or indirectly from this farm.	—	Brit. Med. Jour., vol. ii, 1878, p. 226; *Sanitary Record*, vol. ii, 1878, pp. 100 and 166
100	Aug., 1878, to May, 1879	Selborne, Hants	Dr. Blaxall, L.G.B.	46	3	697	60	23 at least	50	Importation of a case of fever in an adult, with resulting specific fouling of a well common to several households, and so situated as to favour pollution by surface impurities	There were 3 distinct groups of cases; in the first, 7 cases in 4 families using a well which had had opportunity for entry of the specific poison of typhoid from the evacuations of the imported case, a fifth family using the well escaping; as also a sixth family using other water. In the second group, history of like infection by initial case of well and common privy; 16 cases in 7 families out of 10 households similarly circumstanced	In the third group, 23 cases, the disease had become so diffused that no one cause could be thought of as operating, but conditions of well pollution and excrement disposal held to have been the media of spread of infection, as well as chance consumption of water from the specifically polluted wells of the first 2 groups	Brit. Med. Jour., vol. ii, 1879, p. 472.
101	Sept., 1878	Portsmouth	Dr. G. Turner, M.O.H.	153 in whole borough during third quarter	19	113,569	—	78	64 of the cases whose milk supply was ascertained	Dairy clean and well kept; but when supply ran short, extra milk was obtained from a farm a little distance out of the town. At time of epidemic milk supply was actually supplemented in this way. Well of this farm within a few feet of cesspit of a common privy; and water proved on analysis to be unfit for drinking purposes. Farmer's children were suffering from typhoid, and no doubt poisoned the well; for two children who had, while walking, obtained some water at farm, were subsequently attacked by typhoid	Sixty-four per cent. of all the cases in the borough in the third quarter of 1878, whose milk supply could be ascertained, were customers of the dairyman who supplemented his milk from this farm. A large number of the cases fell ill on the same day. The farmer supplied, besides milkman, 20 persons in his neighbourhood; of these, 8 had fever. He also supplied milkman who contracted for mess at Eastney Barracks, which was also invaded by disease. A milkman who lived just outside the barracks supplied quarters of married officers where, too, there were cases of the disease.	—	Brit. Med. Jour., vol. ii, 1879, p. 675.
102	Jan. and Feb., 1879	Redhill and Caterham, Surrey.	Dr. R. Thorne Thorne, L.G.B.	352	21	15,300	About 7,000	All	100	A workman employed in an adit between two deep wells belonging to the Caterham Waterworks ill of enteric fever, and while thus engaged specifically contaminated the workings by his evacuations, which were copious and frequent	Epidemic (save for a few late secondary cases) exclusively in persons using the water. The workman ill of fever continued at his post from Jan. 5 to 20; the attacks became general after an interval of a fortnight, and began to die away after the man ceased work. Large populations closely adjacent to infected districts, but drinking other water, wholly escaped the fever	Infection of the initial case thought of as having been contracted in Croydon, where the man had spent Christmas	Brit. Med. Jour., vol. i, 1879, pp. 248, 279, 320, etc.; vol. ii, 1879, p. 700; vol. i, 1880, p. 82.
103	Jan. to Apl., 1879	Penistone, Yorkshire	Dr. R. Thorne Thorne, L.G.B.	42	5	2,000	—	41	98	A case of fever was introduced from Oldham, the man having a tedious convalescence, with a well-marked and fatal relapse; his movements in Penistone are unknown, but he must have been a source of danger to the community by means of his infectious evacuations. Second case only known to health officer after death. Two of the three principal water supplies open to excremental contamination, both being in the main street near leaky drains	No fever heard of in the users of that one of the 3 water supplies which is a wholesome water. Of the remaining 2 supplies, 1 passes through manured land, and empties through a drain pipe within 10 feet of a midden privy containing sloppy contents. The other draws water from the vicinity of a sloppy midden privy on higher ground, and the pump is close to some square stone drains, and to a sewage-receiving ditch	Other local contaminated wells, and excremental poisoning of air probably helped to keep the disease going	Brit. Med. Jour., vol. ii, 1879, p. 145
104	May to Aug., 1879	Tolcarne, Newquay, Cornwall	Dr. Ballard, L.G.B.	18	2	—	?	All	100	Well so situate that the contents of an adjacent ill-constructed and leaky cesspit soaked into it through the loose surrounding soil. The houses using the well water drained to this cesspit	All the 18 cases occurred in 3 houses, except 2 in lads working at some unfinished houses adjoining those infected The 3 households made use of the implicated water, 12 out of 18 persons being attacked in 1 house, and 5 at least out of 14 persons in another house. All the houses in 1 terrace	Dr. Ballard states his opinion that foul smells from the cesspit outfall pipe on the cliff doubtless also conduced to spread of infection, but that the water was the chief factor	Brit. Med. Jour., vol. i, 1880, p. 642.
105	June to Oct., 1879	Alcester, Warwickshire	Dr. G. H Fosbroke, M.O.H.	36	3	2,400	—	? All	? 100	Water supply partly from wells so situate as to be polluted by surrounding filth	In August heavy floods caused privies and wells to be overflowed, causing washing of foul matters from privy middens into the already polluted subsoil wells. Not one case of fever could be found in houses supplied by the public water service, all the invaded houses using shallow wells. The outbreak, which began in June, spread epidemically in late August. The fever cases were widely distributed over the town	—	Brit. Med. Jour. vol. ii, 1879, p. 1046.
106	Sum-	A Village.	Mr. R. W. Jenkins	7	1	7 cottages	—	All	100	Well situate in close juxtaposition to privies, and polluted thereby	Initial, fatal, case imported, infection thereafter spreading in the house and the two adjoining houses, the inmates of which all drank from one and the same well	—	Brit. Med Jour., vol. ii, 1879, p. 717

107	Aug. Sept., 1879	Swansea	Dr. E. M.O.H.	6[illegible]0	63	65,000	—	All	100	enteric fever admitted to have occurred four months prior to epidemic at a farm on the gathering ground of the Blaenant Ddu reservoir, and conditions prevailed at this farm which rendered pollution of the reservoir probable with the heavy rainfall which was experienced in June and July	districts of the borough, and the surrounding rural areas, not served by the public works, entirely escaped fever	apparently one of short duration, a uniform rise in all the affected districts taking place in the third week of epidemicity, and an equally uniform subsidence setting in thereafter to the end of the fifth week	JOUR., vol. ii, 1879, p. 1046.
108	Sept., 1879, to Feb., 1880	Prittlewell, Essex	Dr. R. Thorne Thorne, L.G.B.	110	?	600	—	All	100	Cases of enteric fever cropped up in early autumn, their bowel discharges being disposed of under generally prevailing conditions which led to contamination in the west and north of the village of the drinking water derived from wells and springs in a porous soil. Cesspools, privies, cowyards and farm yards had no means of drainage except to the surface soil, and leaky drains everywhere alternated with wells. An exceptional rainfall preceded the outbreak	No cause other than water could he assigned as a means of spreading the fever, when once introduced The great stress of the epidemic fell on those parts of the village in which surface soakage of filth to the springs was demonstrated. the east end, which was out of the line of such soakage, almost entirely escaped. The heavy rainfall would carry with it not only an exceptionally large amount of filth to the springs, but filth then specifically infective	About one sixth of the entire population was attacked in a space of six months	BRIT. MED. JOUR., vol. ii, 1880, p. 193.
109	March to Dec., 1880	Hemingbrough, Yorkshire	Mr. J. Spear, L.G.B.	48	8	550	—	47	98	Illness of schoolmistress at board school, with subsequent specific contamination of the school well by means of the adjacent leaky privy into which the bowel discharges had been thrown without previous disinfection. Well also open to receive pollution from drain gulley just above it	Outbreak in its early stages wholly centred. with a single exception. upon school children who had unrestrained access to the well; and after closure of the schools kept up by means of local wells which had received the specific poison of typhoid from these school cases; well-defined and localised groups of cases occurring among consumers of the polluted local supplies	The single exception in the early part of the epidemic was probably imported	Official report to the L.G.B.
110	Mar. to Dec., 1880	Aylstone Park, Whetstone, Narborough, and Enderby (Blaby, R.S.D.)	Dr. Blaxall, L.G.B.	230	30	3,800	—	211	92	In all there were no less than eleven groups occurred in the three villages of Aylstone Park, Whetstone, and Narborough, and in each of them bowel discharges of an initial case of fever had been so disposed of as to specifically contaminate the well water consumed by the invaded households. The situation of the implicated well was in every instance such as to admit of ready percolation of surrounding excremental impurities into the water	The several groups of cases, totalling to 211. were in the three villages already named in each instance in immediate contiguity to a specifically polluted well, and in persons drinking its water, to the exclusion of others	Nineteen cases of fever occurred also in the village of Enderby, but unlike the attacks in neighbouring villages, were related only to specifically contaminated midden privies and poisoning of the air about dwellings	Official report to the L.G.B.
111	April, 1880	Glasgow	Dr. J. B. Russell, M.O.H.	508	69	—	—	373	73	Dairyman concerned got milk from 30 farms; but nothing was found on these to excite suspicion, except on 1. This had a bad health history. Milk house, washing house, kitchen, and living apartments all *en suite*. Bottom of well 3 feet below a pool of stagnant water, and considerably more below a dungheap on which excreta of fever patient were thrown. Dip well at foot of slope from dungheap. Dairyman of this farm sickened with enteric fever in March. Subsequently. 2 children of the farmer were attacked by fever, as well as a girl who partook of milk while passing a night at the farm in nursing her sister (first case), and who sickened fourteen days after Children lay in bedroom next the kitchen. Dairymaid passed through her illness above milk house and washhouse. Excreta thrown over dungheap. Soiled discharges from sick bed washed at dip well. Suspicion that water from this well may have been used for scalding tins and other domestic purposes, pump of other well being somewhat out of order	On the day after sickening of children, first lot of milk from this farm sent to Glasgow. Exactly 14 days afterwards, the first case in area of dairyman's milk supply fell ill. Day by day customers of the dairyman's shop sickened, in numbers increasing until one day a maximum of 38 was reached, and then declining again. Of 40 milkshops supplied by dairyman, fever invaded customers of 30 In one area, 71 cases occurred, all but 1 of the cases drinking this milk. In another area. 57 cases occurred. whilst only 4 cases were found amongst customers of other dairies after an exhaustive house-to house visitation. In another area. out of 292 families, milkshop connected with implicated dairy only supplied 37; yet 15 out of these were invaded. while of the remaining 255 all but 1 escaped. (The 1 case was in all probability a secondary case) "Entire body of trade was tainted. It was associated with fever in dairyman's own household, in persons served direct from his own cart; it poisoned the families of the dealers through whose shops it passed to the public, and it poisoned the customers who dealt at those shops." (Milk supply stopped, and epidemic then died out.)	—	BRIT. MED. JOUR., vol. i, 1880, p. 985.
11a)	April, 1880	Possilpark, Glasgow	Dr. J. Christie	92	—		252 families	90 (in 56 families)	92 of cases, 22 of families	See above (No. 111). Dairyman supplied milkshops in Possilpark also	After very careful examination, no relation could be traced between drainage or water supply of district and the outbreak of fever. Epidemic began just at the same time as at Glasgow. Among persons receiving daily 172 quarts of cream and milk from implicated dairymen, 75 cases of fever occurred; whilst among persons receiving 532 quarts from other or mixed sources, only 17 cases occurred. In only 2 of these 17 cases could the probable drinking of the infected milk be excluded	—	BRIT MED. JOUR., vol. i, 1880, p. 864.
12	May to Nov., 1880	Perth	Dr. A. Simpson, M.O.H.	162	21	26,651	Nearly all	All	100	Water supply from river Tay, carried after filtration, in pipes through river During some repairs the sewage-polluted river water by some mistake was allowed to enter the delivery pipes. which were situate close to the spot where the sewage of the town is discharged to the river	The day succeeding the accident witnessed an outbreak of diarrhœa in the town, this being followed a week later by the fever epidemic	—	Special report of M.O.H.
	2	3	4	5	6	7	8	9	10	11	12	13	14

1	2	3	4	5	6	7	8	9	10	11	12	13	14
No.	Date of Outbreak.	Locality.	Reporter.	Total Number of Cases.	Deaths.	Population of Invaded Locality.	Number of Persons Supplied by Suspected Water.	Number of Cases amongst Drinkers of Suspected Water.	Percentage of Total Cases.	Exciting Cause of Outbreak.	Circumstances Implicating Water.	Observations.	Reference.
113	June to Sept., 1880	Millbrook, Cornwall	Dr. Ballard, L.G.B.	91	3	1,500	—	17	19	An imported case of enteric fever, and a secondary attack in the same house, led to infection of the street sewer; the sewer having connection by an over flow pipe with a well used by several families, and the water of which must of necessity have been contaminated by the contaminated sewer air	Of the seven families next invaded, 5, with 13 cases, were consumers of the well water, and 4 additional attacks occurred later in another family using the well	This infected well indirectly caused a further and widespread extension of fever, since the invaded families used privies discharging to a square drain which had aërial connection with the storage room of a dairy, on the shelves of which milk was habitually set in pans. The milk was thus exposed to the emanations from a drain containing the specific bowel discharges of fever patients. Six of the dairyman's family were attacked, and an unknown number of his customers, 22 being traced. The sale of this milk was never stopped. Ample facilities for spread of the malady from person to person and by drainage and water arrangements existed "until the whole village has become steeped with the contagium"	BRIT. MED. JOUR., vol. ii, 1880, p. 724; vol. i, 1881, p. 20.
114	July to Oct., 1880	Scalby, Yorkshire	Mr. J. Spear, L.G.B.	20	—	176	—	11 at least	55	Well resorted to by school children obviously polluted by the soakage from adjoining privies and drains of two cottages. Well shallow, and sunk in a porous, sandy soil, and only loosely bricked. First suspicious case of fever occurred in one of these cottages, and was attended by persistent diarrhœa	Of the 20 persons attacked, 11 were known to have drunk from the cottage well, 3 others had probably done so, and the remaining 6 were secondary attacks. The school children came from different parts of the parish, and after the school was closed no further case occurred among them	—	Official report to the L.G.B.
115	Aug. to Dec., 1880	Haverfordwest	Dr H. F Parsons, L.G B.	88	7	6,622	—	42	48	The precise cause operating to cause the epidemic could not be demonstrated but one section of the public water service—Portfield—was liable to pollution both at its point of storage and in its line of distribution; especially since intermittency of supply enabled foreign matter to find entry into the main by insuction caused by the vacuum; the mains at places intersect the sewers, and service pipes on occasion go through house drains. Indraught of air and insuction of sewer contents demonstrated. Some of the valves from the water mains for flushing the sewers found to be leaky and incapable of perfect closure. Surroundings of storage reservoir of the other—Fountain—section of the public water service also dangerous; and the same is true of many private wells	Sudden outburst of fever in divers parts of the town; 13 of 17 cases in August being in consumers of the Portfield water; 42 patients in all took this water; other 19 chiefly used the other—Fountain—supply; 16 used wells, brooks, river, etc. The two public sections communicate by valves, and at times the mains are wholly filled by Portfield water. In 20 cases the patients were female servants, considered to be large water drinkers	Once the fever was set going, its dissemination rendered easy by the prevailing conditions of excrement disposal, sewerage, and house drainage, leading to poisonous exhalations.	BRIT. MED. JOUR, vol. ii, 1880, pp. 786, 819.
116	Sept., 1880	Rochdale	Dr. Joseph Henry, M.O.H.	35	9	68,866	—	26	74	Well at farm, used for all culinary purposes, is underneath the kitchen, and about 15 yards deep. Well was not puddled, and admittedly received sewage. Analysis showed it to be polluted. In a cottage between the farmhouse and ship-pen a woman had been suffering from typhoid fever. Her excreta dangerously disposed of in relation to well	Outbreak occurred suddenly, and ceased as suddenly. Of 35 cases of fever in a particular district, 25 were found to have had their milk from the suspected dairy. Cases occurred about a fortnight after the case at the farm	—	BRIT. MED. JOUR., vol. ii, 1880, p. 597
117	Sept. to Oct., 1880	Bridlington, Yorks	Dr. Allison, M.O.H.	48+?	8	8,321	83 families	48	Very large majority	Well of private farm situate in a gravelly soil in a low-lying situation, admitting of soakage from under-drained field. Sewage flows to an open ditch, at the bottom of adjacent gardens, from several houses, in one of which a case of fever recently occurred	Of 48 known cases of undoubted typhoid, all occurred in houses getting milk from the same farm. In addition, 7 doubtful cases also among consumers of the implicated milk.	"Other cases of fever," number not being known apparently, occurred in houses not taking the milk, the health officer laying stress on the prevailing methods of excrement disposal as conducive to the spread of fever.	BRIT. MED. JOUR., vol. ii 1880, p. 786
118	Sept. to Oct., 1880	Newlyn, Cornwall	Dr. Ballard, L.G.B.	99	9	650	Nearly all	57 ?	58	Contamination of the "Town Well," the contents of which and of the contiguous and only main drain made free interchange, and the level of the water being the same in both. The exact source of the specific contamination of the well not discovered. (The outbreak had been kept from outside knowledge by order of the sanitary authority)	All the early cases in the outbreak drank from the Town Well, the invaded families having nothing else in common. A fortnight after the pump was closed the daily number of attacks fell by nearly two-thirds	Other water supplies subject to grave risk of excremental pollution, and these and the deplorable conditions of excrement disposal, the poisoning of air, and the infection of milk by use of the well water, kept up the epidemic	BRIT. MED. JOUR., vol. ii, 1880, pp. 670, 724; 749, 787; 819; vol. i, 1881, p. 178.
119	Sept. to Oct., 1880	Ystalyfera, Glamorganshire	Dr. H. F. Parsons, L.G.B.	100	?	4,728	30 to 40 houses	38	38	Percolation into a stream of water, delivering to a cistern, and used for drinking purposes, of the contents of a cesspit which had received the copious	Of some 30 to 40 houses using the polluted stream 27 were invaded by fever within a space of seven weeks, all cases being in water drinkers. A fortnight after closure of the suspected cistern the outbreak in former consumers of its water ceased	Epidemic kept going by personal infection, other polluted water supplies, and emanations from foul and specifically-infected privies and gut-	BRIT. MED. JOUR., vol. ii, 1880, p. 724.

1	2	3	4	5	6	7	8	9	10	11	12	13	14
120	Sept. 1880	Brid-	Dr.	103			—			a gravelly soil, in a low-lying and, in wet weather, swampy, underdrained field, where a downward percolation would readily take place. Well but a few feet from cowshed, and from a huge pile of manure. Two privies with covered middens were only 13 yards distant. Analyst reported water as very bad, and "evidently largely contaminated with sewage." The dairyman's son's wife had suffered from typhoid fever in August, and had been to her father-in-law's house after her recovery. Three cases of fever occurred in the early part of October, in the house adjoining the dairyman's	cases. Of 60 households invaded in September and October, 45 were consumers of the milk. The outbreak was sudden and widespread, and attacked only the milk walk of this vendor. When attention was called to the state of the dairy, the well was filled up, and company's water substituted. After this the number of new cases of fever in fresh households rapidly declined	sanitary conditions	ii, 1880, p. 786
121	Sept. to Oct., 1880	Rochdale, Lancs.	Dr. Henry, M.O.H.	50	10	63,866	—	26	52	Well at dairy farm 15 yards deep, and situate beneath the kitchen. Water in well, which was used for all culinary and dairying purposes, found to be grossly polluted. A case of fever in an adjacent cottage, the stools of the patient being frequently thrown into a cesspool, the dip of the soil thence being towards the well. Well unpuddled and partly fed by surface water	Of the 50 cases of fever, 35 occurred in a particular locality, and of these no less than 26 were among consumers of milk from the implicated farm, 9 being fatal. There was 10 per cent. of added water in the milk as delivered in the town (? from polluted well)	Surveyor doubted the possibility of soakage from the cesspool, but failed otherwise to explain the contamination of the water by sewage	BRIT. MED. JOUR., vol. ii, 1880, pp. 597, 621, 629, 670.
122	Sept., 1880, to Mar., 1881	Uckfield, Sussex	Mr. W. H. Power, L.G.B.	38	5	2,000	All	All	100	Water supply of Uckfield from wells sunk in a soil saturated with excremental filth, and open by means of fissures and badly-made drains, privies, cesspools, and the like, to receive specific pollution whenever fever excreta were disposed of	Outbreak began in September, with spread until January, when there was rapid increase, the escape of air from specifically infected sewers being thought as having conduced to spread of the fever, as well as wells befouled with the poison of typhoid from the evacuations of patients treated at home. One well, which was obviously fouled by an adjacent leaky privy which had received excrement of enteric fever, supplied only a limited number of households, and among these 10 attacks occurred within a very short space of time	All the fever cases were treated at home amid surroundings of a sort specially conducing to spread of filth diseases	BRIT. MED. JOUR., vol. ii, 1881, p. 414.
123	Oct. and Nov., 1880	South-port	Dr. H. H. Vernon, M.O.H.	32	2	32,206	—	All	100	Well on dairy farm (several miles distant) grossly polluted by sewage; water on analysis found to be "nothing but liquid sewage"	All the cases were among consumers of milk from this one dairy farm. Stoppage of the milk supply caused cessation of the epidemic.	The invaded houses were in a good sanitary condition; only slight defects found in 2	BRIT. MED. JOUR., vol. ii, 1880, pp. 820, 934
124	Oct. and Nov., 1880	Worthing, Sussex	Dr. Kelly, M.O.H.	44	8	10 976	—	All	100	Well at dairyman's house, and common to two adjoining houses, showed on examination palpable soakage in the direction of the house in which a case of fever developed in late September. The excreta from this patient thrown down the drains, some of the infective discharges having doubtless gained access to the well water, this water being used for the washing out of milk cans, despite the fact that town water was laid on to the house	All the known cases were in consumers of milk from this dairyman's premises. As showing that the milk became infected at the dairy, the fact was ascertained that milk from the same farms distributed at Worthing and elsewhere by other milk vendors did not cause fever	Those persons drinking most milk suffered most severely, the poor almost wholly escaping	BRIT. MED. JOUR., vol. ii, 1880, p. 933.
125	Dec., 1880, to April, 1881	Tandragee co. Armagh	Mr. J. Taylor, M.O. of Dispensary	208	22	118	1,100, including mill, school, etc.	All	100	Emptying of dejecta of a typhoid patient into a stream 100 yards above the water supply, which was itself a few yards from the stream. Well sunk in a porous soil; the adjacent stream being, moreover, used as a sewer by half the town	The water supply was cut off on December 13th; all the cases to that date having been users of the supply, and suspicion aroused. After January 17th all new cases were traceable as secondary occurrences. Many persons in a mill and at school, drinking the polluted water, were attacked in their homes in the country, the other members of their households escaping	Delay in reporting the facts owing to compilation of facts from official registers	BRIT. MED. JOUR., vol. i, 1881, pp. 65, 99, 135, 141, 169, 207, 218; vol. ii, 1893, pp. 1373-74.
126	Jan. to to May, 1881	Belthorn, Lancashire	Dr. Airy, L.G.B.	23, and some others not enumerated	?	Some 400	—	All	100	Chief water supply of the village open to pollution by the soakage from a cluster of privies on the hillside. Privy contents never need removal, owing to leaky state and absorption. Rock much fissured.	All the cases were located round the roadside spout of the water supply in question, which furnished the source for all purposes. Dangerous situation of the water in relation to excremental pollution fully appreciated by its users. A household in another part of the village deriving water from the same source by a separate pipe attacked in the winter preceding the general outbreak	—	Official report to the L.G.B.
127	Jan., 1881, to Sept., 1882	Dartford, Kent	Mr. J. Spear, L.G.B.	103	14	10,159	1,620 (?)	74	73	Local wells sunk in an excrementally polluted soil. Pumping operations in low lying district undertaken in 1880-81 to lower the subsoil water for purposes of sewer laying resulted in draining away the liquid of cesspools, the certain result on the entrance of fresh water on subsequent fluctuations of subsoil water being the exceptional contaminations of wells in passage of the water through fresh layers of soil thus fouled. Original case led to specific fouling of one of these local wells	Outbreak of fever followed the pumping operations, and was almost entirely confined to the district in question. In 324 houses using local wells, 74 attacks occurred; in 500 houses using public supply only 16 cases discovered. Respective percentages of household invasions, 13 and 2½. Of 6 cottages using one well specifically polluted by first case, 5 invaded before the well was closed, 16 cases occurring. Excrement of cases improperly disposed of in stagnant ditch hard by, other attacks following in the immediate vicinity, the water being drawn from surface wells.	Although it was the polluted wells in the low-lying parts of Dartford which had exerted this influence on the spread of fever, yet in the higher parts, despite their greater depth, wells were not protected from surface drainage, and imminent danger of soakage from cesspools and privies existed	Official report to the L.G.B.
128	Feb. to May, 1881	Blackburn	Dr. Airy, L.G.B.	260	42	104,000	All	All	100	Public water service from 3 reservoirs and a deep well, subject to serious contamination, especially at the gathering ground and along the route to the town. Culvert particularly exposed to sewage contamination from houses in one of which a case of enteric fever was treated in February. Soakage of sewage into the culvert demonstrated at this point of its course	Enteric fever suddenly blazed out in March, with 149 cases, followed by 61 in April. The various sections of the water service in the latter end of February contained admixture of water passing through the culvert undoubtedly specifically fouled by typhoid excreta, the epidemic being heaviest on the section deriving supply from the reservoir chiefly concerned. Heavy rainfall preceded the fever; and this, too, may have been a factor in the case, looking to the conditions obtaining at the gathering ground. The incidence of fever on population very slight, and widely diffused, with but few severe cases, this favouring the theory of large dilution of the poison, which relatively to the body of water must have been minute, if the excreta from a single case were only in reality in question	Other likely causes of the outbreak were found on investigation to have been incapable of such causation	Official report to the L.G.B.

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No.	Date of Outbreak.	Locality.	Reporter.	Total Number of Cases.	Deaths.	Population of Invaded Locality.	Number of Persons Supplied by Suspected Water.	Number of Cases amongst Drinkers of Suspected Water.	Percentage of Total Cases.	Exciting Cause of Outbreak.	Circumstances Implicating Water.	Observations.	Reference.
129	April, 1881	Aberdeen	Dr. Beveridge	322	3	—	112 families	All	100	Cistern at dairy farm, supplying water for all byre and dairy purposes, situate in a corner of the cowshed. Water on entering the cistern found to be pure, but analysis showed it to be highly polluted in the cistern with organic matter. Various circumstances pointed to admixture of the water and milk, as well as the washing of cans with the water	All the cases occurred in consumers of the milk, and were widely scattered in point of locality, though the bulk occurred in little more than a week, no cases occurring outside families dealing with the dairy farm. Milk supply the only circumstance common to all. In most instances the majority of the members of invaded families were attacked. Immunity of some of the households using the milk could be accounted for owing to peculiar circumstances. Consumers whose milk vessels were not washed in the cistern water escaped the fever. Of the 112 families taking the milk, 89 were invaded, being at the rate of nearly 80 per cent.	During the period of infectivity of the milk, Professor Cossar Ewart discovered in it organisms identical with those in the cistern water. Nothing discovered amiss with the cows after very careful examination	BRIT. MED. JOUR., vol. ii, 1881, pp. 329, 515, 874, 912, 949, 1062
130	Spring, 1881	Bridgeton, St. Vigeans, Scotland	Dr J. S. Crichton	16	Several	50	(?) All	All	100	Well contaminated by surface water from manured fields. Water found to be very bad on analysis	One-third of entire population attacked. Only 3 families in the immediate neighbourhood escaped invasion	—	BRIT. MED. JOUR., vol. i, 1881, p. 822
131	July and Aug., 1881	Bodeeve, Bodmin R.S.D.	Dr. H. F. Parsons, L.G.B.	5	2	4 cottages	All	All	100	Pump-well situated in lobby of one of the cottages, and liable to contamination by privy with open cesspit, dilapidated and in foul condition. Privy 20 feet from well, and on higher ground. Offensive smell perceptible by pump; water contains suspended articles	Fever limited to the four cottages using the well. First case died on July 1st, and the second on the 19th. All the patients made use of the one privy, which the health officer regarded as having polluted the well water.	—	Official report to the L.G.B.
132	Aug. to Nov., 1881	Lower Stoke. Hoo R.S.D., Kent	Dr. Airy, L.G.B.	17	nil	570	—	All	100	Spring delivering to half-cask sunk in the back yard of some private premises and thence to another sunk close to the edge of a sewage polluted stream. Danger in flood time of stream overflowing the barrel. And barrel also contaminated by means of a drain pipe bringing down the soakings from adjacent stable and other refuse	The outbreak was localised to some cottages in Lower Stoke, the first case occurring at an inn having a well contaminated by drainage, and "seldom used except for washing." Outbreak due probably to specific contamination of the "barrel" water, either by means of the refuse draining to it or by infiltration from or flooding of the sewage polluted brook close by.	No community of condition other than water supply to the invaded houses	Official report to the L.G.B.
133	Sept., to Dec., 1881	Ulverston, Lancs.	Mr. J. Spear, L.G.B.	42	7	10,000	—	All	100	Water drawn by many persons from a spring, the feeders being crossed by the town sewers. Spring largely fed by surface water. Just prior to outbreak a great rain storm flooded the sewers, their contents no doubt in part escaping to the surrounding soil. The storm water also rushed past a privy, containing the evacuations of the initial typhoid patient, in the vicinity of the well	Thirty cases occurred, chiefly among users of this spring water, in a locality consisting of a few rows of houses during the four months, against only 12 in the remainder of the town; 5 out of 8 outlying cottages using the water were invaded; and the initial sufferer at a neighbouring farm was one who used it during a visit to the district. Other cases in persons known to have drunk of the water were heard of. No other common origin of the prevalence could be discovered.	Similar explanation of other fever outbreaks in the town presents itself, not only as regards 1881, but former years also. Turbidity of public service had led to use of local sources of supply, with associated outbursts of fever	Official report to the L.G.B.
134	Dec., 1881, to Jan., 1882	Harewood Terrace, Norwood, Uxbridge R.S.D.	Mr. W. H. Power, L.G.B.	29	nil	148	97	All	100	Two pumps used by certain inhabitants in the upper part of the terrace sucked from a single well, open to pollution by means of cesspool contents emptied into a hole dug in a garden some 40 feet from, and on higher ground than, the well, and in the line of natural soakage thereto. Five cases of fever occurred in August to October in houses using cesspools the contents of which were in early December emptied as described above	Shortly after the cesspool emptying the second fever outbreak commenced, 14 out of 17 houses using the two polluted wells being invaded, and 36 per cent. of the residents attacked	Of the inmates aged between 5 and 15 years of age, 69 per cent. were sufferers	Official report to the L.G.B.
135	1881	North Tawton, Okehampton R.S.D.	Dr. Blaxall, L.G.B.	15	2	1868	—	All	100	Pump in yard in rear of cottages, slop drain leading thence from privy, which discharges into a stream. Linen soiled by discharges of initial fever case washed at home and the water emptied into this slop drain, thus specifically fouling the well.	Every family subsequently using the well water was invaded. Families in the vicinity, using other water, escaped	—	Official report to the L.G.B.
136	March to April, 1882	Sherborne Dorset	Dr. Blaxall, L.G.B.	10	nil	5,000	Many hundreds	10	100	Antecedent cases of enteric fever in Sherborne led to specific infection of sewers by untreated bowel discharges of the sick, the sewer in the vicinity of the invaded houses being so laid as to lead to accumulation of sewage. This sewer flushed 14 days prior to outbreak and in such manner as to force the foul air through any weak traps or available openings. Water supplied to invaded houses open to the danger of entrance of sewer air by way of the closet pan (in direct connection) and of sinks	Conditions of water service in 4 adjoining houses identical, and such as to favour insuction to the pipes or sewer air; the method of distribution being in these respects singular to these houses. Outbreak in 3 of these (school) houses, all cases among water drinkers; water drawn from the sink taps. No cases among pupils after early closure of school. The inmates of the fourth house, occupied by 5 adult non water drinkers, alone escaped infection. Analysis of water on school premises confirmed belief of sewage contamination	Widespread and fatal epidemic in Sherborne in 1873, traced to direct communication between water mains and water-closets, had led to remedy of this defect generally over the town. Limited dimensions of present outbreak attributed to this fact	Official report to the L.G.B.
137	April, 1882	Leicester Infirmary	Dr. Buck,	12	2	—	—	All	100	Well at farm situate near leaky cesspool, and near the end of house drain. Water	All the patients had consumed in its raw state milk coming from this farm. The farmer and milk vendor also attacked.	Institution found to be in good sanitary condition	BRIT. MED. JOUR., vol. i, 1882, p.

	and 1882	Cowick, R.S.D.	Mitchell M.O.H.				out of families			ing off waste water from the gulley against the pump of the well. Leak from gulley to well discovered. Privy common to invaded houses connected with an uncovered ash-hole 20 yards from and on a higher level than well. Specific fouling of well thus possible in two ways	houses, 3, or 12 per cent., invaded, and infection of these easily explainable, 1 as probably caught by use of the well water at a relative's house and the other 2 by infection	with excrement of patients, at a later stage of the epidemic	ii, 1882, p. 691
139	June, 1882	Clapham	Dr. Parsons	20	4	—	118 households	19	95	Fever at Musbury, near Axminster, the last case recovering about the end of March. Excreta so disposed of in a vault of primitive construction and then flushed out as to render pollution imminent of well on farm supplying milk to a Clapham milk dealer Analysis of well water showed it to be largely polluted by sewage, doubtless the result of percolation from the sewage-polluted brook which received the sewage of Musbury	All the cases, save 1, occurred in consumers of the milk from the dairy man having his supply from this Musbury farm. Persons attacked were mostly drinkers of milk in its raw state, in some cases being the chief drinkers. One boy engaged at the milkshop was the only member of his household attacked, he being allowed a pint of milk daily and consuming it himself. The fever ceased a few days after the stoppage of the Musbury milk supply	The persons affected were mostly children. The number of attacks seemed to bear relation to the amount of milk used	BRIT. MED. JOUR., vol. ii, 1882, p. 816.
140	July to Aug., 1882	Galgate, Lancashire	Dr. F. W Barry, L.G.B.	19	2	743	51	All	100	Well undoubtedly excrementally polluted	All the persons attacked used the one well. The percentage of attacks to residents in houses so supplied was 37.2. The percentages of persons of varying ages were 5 to 15 years, 67; 15 to 25 years, 41; 25 to 40 years, 36; and 40 and upwards, 29 per cent. After disuse of the well no further cases occurred	The precise method of excremental pollution could not be ascertained owing to absence of the medical man attending the earlier cases and of the persons themselves	Official report to the L.G.B.
141	July to Sept., 1882	Bangor, Carnarvon	Dr. Barry, L.G.B.	548	42	8,247	?	All	100	The excreta from 3 typhoid cases in May were deposited in a creek at the back of dwellings, whence they passed by means of a rubble drain into a rapid stream, which feeds the river whence Bangor derived its supply, the distance from the invaded houses to the intake being only 700 yards. The bursting of a main in early July, with consequent disturbance of reservoir and filter-bed, was followed by a simultaneous and sudden outbreak of fever in various localities	Fever was entirely absent from houses not served by the public water supply. The water was much discoloured after the bursting of the main and smelt badly. The filtering beds were very inefficient and dirty; no doubt arising from the accumulated dirt carried into the reservoir and thence to the main as the result of the accident. It was after the lapse of ten days to a fortnight that fever suddenly blazed forth. Earlier dropping cases of the disease had led the local health officer to the conclusion that pollution at the intake was in question	Subsequent general diffusion of the epidemic was assisted by faulty ventilation of sewers and house drains, and foul accumulations of excremental refuse in the town. Numerous sources of pollution above the intake were discovered	BRIT. MED. JOUR., vol. ii, 1882, pp. 815, etc.
142	July to Dec., 1882	Abertillery, Monmouth	Mr. J. Spear, L.G.B.	61	13	6,000	—	40	66	Water supply of invaded locality, different from the town service, is a spring issuing from the base of a fissured sand-stone hill, and subject to pollution by drainage from cottages (in one of which the first case of fever occurred), a graveyard, and a small village	Two-thirds of the cases occurred in one circumscribed locality of about 100 houses; all infected families in this locality drank the implicated water. The village above, with a separate supply, escaped; whilst cottages lower down the hill and drawing water from the fissured sand stone, had 9 attacks	The remaining 11 cases were of later occurrence and distributed impartially over the remainder of the district, amid gross insanitary surroundings	Official report to the L.G.B.
143	Aug., 1882	Evesham and adjacent villages	Dr. G. H. Fosbroke, M.O.H.	69	6	—	—	? 46	67	Well seriously contaminated by animal organic matter. Well some 30 feet from a sewer, in a low-lying meadow, the water on examination showing signs of undoubted pollution	Fever scattered through 11 villages. All the persons attacked prior to the general diffusion of the disease had attended the local regatta, and had visited this particular meadow, no case of fever occurring in persons who had thronged the only other largely frequented locality. Of the 46 persons thus early attacked, 32 certainly, and 11 others probably, had drunk of this well water, mixed either with spirit or in the form of lemonade or ices. One party of three persons was attacked in the two who had made use of the well to the exclusion of the third who did not use it.	With so many foci of disease, secondary cases of necessity arose later	BRIT. MED. JOUR., vol. ii, 1882, pp. 497, 1268.
144	Nov., 1882 to Jan. 1883	Great Ilford, Essex,	Dr H. F Parsons, L.G B.	27 households	?	—	—	26 in epidemic period	84	Pollution of well at a dairy farm by means of a cesspit privy. A case of illness at the farm in November, attended during two days by looseness of the bowels. Disease not regarded as typhoid	Five households in widely-separated localities invaded within a few days of each other; further outbreak, affecting 16 houses in December. Of 18 of the houses, 16 are known to have had their milk from the farm in question, which, however, supplied over 200 families. In these 16 houses occurred 26 out of 31 known cases	Fever once diffused kept going by gross insanitary condition of town, 'ripe for the outbreak of a serious epidemic of typhoid fever should the germs of the disease be introduced'	Official report to the L.G.B.
145	Dec., 1882, to Jan., 1883	Hitchin	Mr. W. H. Power, L.G.B.	100	7	8,434	6,000	Majority	Large	Epidemic associated with defects at the pumping station permitting back flow into the well of the water of the river Hiz, a stream "hardly more than a ditch" receiving refuse and excremental matter from adjacent houses	All causes other than water excluded. Two epidemic outbursts, one in December, the second in January, the latter preceded by a flood with resulting back flow of water to pumping well, the disease suddenly ceasing on remedy of defect. December outbreak related to a like circumstance, with cessation of fever after closing of well. Drinkers of well water, located and living under other conditions similar to public water consumers, escaped the fever, save where in a few cases opportunities for its partial consumption were afforded	Fever once started kept going by grave defects of public sewerage and private drainage	Official report to the L.G.B.
146	Spring 1883	Barnoldswick, Yorkshire	Dr. Atkinson M.O.H.	48	8	—	—	Majority	—	Well fed from ground which was situate between two sets of cesspools which intercommunicated, the ground being saturated with sewage. Water found to be highly charged with organic matter. Moreover, fever cases occurred in houses draining to these cesspools, into which the dejecta were cast. Water from well pumped to a cistern at the "new mill," under conditions conducive to further pollution by specific excremental material	Initial case a mill hand attacked a few days before his return from a holiday; and the majority of the first cases mill workers. Some are known to have continued at work during the earlier stages of the fever, thus leading to pollution of the mill privies, which discharge their contents by a single open shaft to a cesspool below. Most of the operatives live in houses draining to the cesspools mentioned in Col. 11	The mill privies, situate one above the other on every storey, gave rise to noxious smell in the workrooms owing to strong draught up the open filth-lined shaft	BRIT. MED. JOUR., vol. i, 1883, p. 1013.
147	July to Oct., 1883	Torpoint, St. Germans's, R.S.D., Cornwall	Dr. J. B. Kerswill, M.O.H.	152	7	2,500	All	All	100	The whole village dependent on shallow wells, which are all more or less polluted	Many of the cases were traced to the drinking of water from a particular well in a square, the water of which was found on analysis to be much polluted. Moreover, the drainage of the place was very defective, most of the drains being of old mason work, broken down and allowing free percolation of their contents, thereby contributing to the contamination of the wells.	—	BRIT. MED. JOUR., vol. ii, p. 343.
		3		5	6	7	8	9	10	11	12	13	14

1	2	3	4	5	6	7	8	9	10	11	12	13	14
No.	Date of Outbreak.	Locality.	Reporter.	Total Number of Cases.	Deaths.	Population of Invaded Locality.	Number of Persons Supplied by Suspected Water.	Number of Cases amongst Drinkers of Suspected Water.	Percentage of Total Cases.	Exciting Cause of Outbreak.	Circumstances Implicating Water.	Observations.	Reference.
148	Aug. to end of 1883	Abertillery, Monmouth	Mr. J. Spear, L.G.B.	500	20	6,160	—	—	—	Epidemic outburst confined to localities where gross sewage nuisances prevailed, and where water supply was drawn from highly dangerous sources	First serious outbreak associated with entire absence of sewers and of proper privy accommodation, and with water supplies from small rills exposed to excremental pollution. Among other defects a mountain rill serving a considerable district for washing purposes, and at times admittedly for drinking purposes, washed over the floor of a privy pit containing human excrement. This district was later on deeply infected, 42 households being invaded in four streets	Disease doubtless assisted by excremental nuisances as well as polluted water supplies; and after its local epidemic outburst became widely diffused	Official report to the L.G.B.
149	Nov., 1883, to Jan., 1884	Dagenham, Essex	Dr. H. F. Parsons, L.G.B.	11	?	Of invaded locality about 150	About 115	All	100	Pollution of well by means of the soakage of filth round the pump, which had no trough. Such soakage demonstrated by disposal of paraffin oil poured on the ground at the pump. It was the habit of persons to wash dirty utensils at this spot	In the invaded locality, two wells in use; all the sufferers drank the implicated water	Effluvia from an adjacent ditch thought of locally as the cause of the fever; but the houses nearest the ditch wholly escaped invasion	Official report to the L.G.B.
150	Jan., 1884	Aberdeen	Dr. Simpson, M.O.H.	25	2	—	—	All	100	Milk supplied from a farm, the pails and other dairy utensils being washed in an adjacent stream. This stream water found to contain an excessive quantity of albuminoid ammonia derived from sewage, the overflow of a school cesspool, and the drainage of manured fields	The fever confined to consumers of the milk from this farm	All other known causes of fever could be set aside	BRIT. MED. JOUR., vol. i, 1884, pp. 76, 124, 184
151	Jan. to Mar., 1884	Cowpen, Northumberland	Drs. Ward, M.O.H., and H. F. Parsons, L.G.B.	74	13	10 000	—	74	100	Pollution of Hepscott water service by the Catchburn stream, which received the drainage of highly manured fields, on which human excreta had been thrown among other filth. Outbreak preceded by heavy rain	Incidence of fever on consumers of Hepscott water very heavy, both town district and villages taking the water, and they alone, suffering heavily, closely adjoining places otherwise supplied escaping invasion. The fever ceased when the Catchburn supply was cut off	—	Official report to the L.G.B.
152	June to Aug., 1884	Beverley, Yorkshire	Dr. D. Page, L.G.B.	282	15	12,440	About 1,250 (186 houses and institutions)	97 houses	52	Cases of enteric fever occurred in the East Riding County Lunatic Asylum prior to the general outbreak, the sewage of the institution being disposed of by irrigation at irregular intervals over a field contiguous to town well and reservoir. Specific contamination of water supply held to have resulted, since the untreated evacuations of the asylum fever cases were thrown down the water closets draining to the sewage farm	Within three weeks of the outbreak, which appeared suddenly and simultaneously in widely different parts of the town, and in houses variously circumstanced except as to water, 68 persons were attacked, 66 being drinkers of the waterworks' supply from the well near the asylum sewage farm. Among 186 scholars at the only elementary school to which this water is laid on, 15 cases occurred, against 5 among 785 scholars of other schools. At the workhouse and porter's cottage, having the same water supply, 16 persons, 15 being children, attacked on same day, non-water drinkers escaping. At the asylum, 39 cases, all in consumers of the town water, occurred during the epidemic period. Incidence upon town water drinkers at least 32 times greater than on persons using other water	Later maintenance of fever owing to secondary infection, sewer air from infected sewers, and other local insanitary conditions about dwellings. Relations of water mains and sewers a source of grave danger	Report of Med. Officer, L.G.B., 1884.
153	July to Dec., 1884	Newark	Dr. H. F. Parsons, L.G.B.	93	12	14,610	All	All	100	Public water supply from collecting well close to the stream of the river Trent already largely polluted by sewage from numerous populous towns. Analyses of the drinking water reveal a larger amount of chlorine in the wells near the river than at tap in the town. Water supply also largely from shallow wells subject to soakage from leaky drains, privies, etc., especially in the populous districts. Enteric fever endemic in Newark, and methods of excrement disposal faulty in places	Enteric fever attacks especially numerous in July and August all over the town, but with tendency to grouping in certain localities. In one yard of 6 houses and 29 inmates, 5 houses and 13 persons attacked, after importation of the initial case, the excreta from which were thrown into a large ashpit connected with three privies, 16 feet from the well. Water of well proved later by analysis to be contaminated by soakage. Majority of cases among persons using shallow wells; others using tap water. Cases occurred on 5 out of 7 separate sewer systems	Outbreak no doubt due in part to other unwholesome conditions obtaining in Newark	Official report to the L.G.B.
154	Aug. to Sept., 1884	Glasgow Hospitals.	Dr. J. B. Russell, M.O.H.	104	?	Three institutions	All	All	100	Milk supply in common from 40 farms scattered over several counties. At one farm cattle ill through consumption of had drinking water. Water from stream into which runs the sewage of the villages of Fergushill and Bensley, where over 100 cases of fever had arisen within two years in a population of 1,000 persons. Water found to be grossly contaminated with sewage products.	Fever confined to inmates and staff of these institutions, and to a few persons outside who all had the same milk. A dairymaid at the implicated farm also attacked at same time	Dr. Milroy, of Kilwinning, regards the epidemic at Fergushill and Beusley as due to the deposit near the pump well of Bensley of manure from Glasgow. This led to temporary disuse of the water by the villagers; resumption at a later date being followed by smart attacks of fever, culminating in an epidemic prevalence, and causing 6 deaths. The manure held to have contained the specific germs of typhoid fever.	BRIT. MED. JOUR., vol. ii, 1884, pp. 550, 673, 724
155	Aug. to Nov., 1884	Hebden Bridge, Yorkshire	Dr. Gresswell, L.G.B.	23 households	14	5,000	135 houses	20 households	87	Pollution of the Birchcliffe water system by the drainage of highly manured fields, overspread with human and animal excreta and other filth. Water also open to pollution by privy pits, manure heaps, etc. Heavy rainfall just antecedent to outbreak	The first five families attacked were widely scattered and alike only in the matter of water service. In the epidemic period, of 23 infected tenements, only 3 not using Birchcliffe water were invaded, and other methods of infection could be traced. The incidence of invasion of the Birchcliffe section was 15 per cent. of houses; in the rest of the district less than 1 per cent.	Fever kept going at end of epidemic period by means of overcrowding, defective ventilation, sewer-polluted air, and local water pollution everywhere prevalent.	BRIT. MED. JOUR., vol. i, 1885, p. 1071.
156	Aug. to Nov., 1884	Langworth, Lincoln R.S.D.	Dr. Gresswell, L.G.B.	10	3	—	—	All	100	Most of the village sewage passes into the beck furnishing the chief water supply. In June or July, while the beck was running low, the sewage percolated through the loose rubble round the water pipes, which had been lately defectively relaid in the bed of the	Initial case arose in Langworth, and all the others living in three houses drank of the beck water. Milk excluded as a factor. After the leakage of sewage into the pipes had been discovered and stopped, no other family was attacked	—	Official report to the L.G.B.

	1884		M.O.H.							ditch which received the farmhouse drainage, as well as from three houses above. Ditch terminated in what was in reality "an open cesspool." Four cases of fever at the farmhouse during the preceding two months	farm in question	in about a fortnight	ii, 1884, pp. 668, 786, 826.
158	Oct. to Dec., 1884	Falding-worth, Lincoln R.S.D.	Dr. Gress-well, L.G.B.	12	1	310	—	All	100	Pollution of local well by the water used for washing the linen of the initial (imported) case of enteric fever	All the cases that followed were among users of the well, and other likely causes were excluded as accounting for the outbreak. Three of the patients fell ill in as many successive days. No further attack occurred after closure of the well	—	Official report to the L.G.B.
159	Oct., 1884 to Jan. 1885	Market Weighton, Yorkshire	Mr. A. Royle, C.B., L.G.B.	74	4	1,881	—	All	100	Water supply either from shallow wells sunk in the bed above lias clay or from stored rain water. Four public wells, all liable to pollution. One opened, and sewage found soaking into it from sewer two yards distant. Drought of last autumn lowered the surface water; leaky sewers, cesspools, privies, fold yards, etc., continuing to add their pollutions to the water-bearing strata	Mr. Royle regarded the drinking water as unquestionably the chief factor in the spread of the fever	—	BRIT. MED. JOUR., vol. i, 1885, pp. 341, 513, 625
160	Jan. to Feb., 1885	Church End, Cambs.	Dr. Bushell Anuing-son, M.O.H.	66	6	2,458	—	All	100	Feed well fed by water which ran along a path in a bad sanitary state, and with adjacent cottages in bad condition. Two cases of fever had occurred "at the top and bottom" of this by-path, and the water at the well was found on analysis to be seriously polluted whilst pure at its source	Fever confined to the portion of the village served by water from three feed wells of which the polluted well was one; evidence of pollution of the remaining two wanting. Two cases at remote parts of the parish distinctly traced to infection derived at Church End	—	BRIT. MED. JOUR., vol. i, 1885, p. 842.
161	June and July, 1885	Swansea	Dr. E. Davies, M.O.H.	549	18	72,458	—	All	100	Excreta from typhoid cases were, it is assumed, contaminating the soil surrounding three farmsteads on the gathering ground of the Lliw reservoir in early June; and the rainfall at that time was such that the specific material of typhoid could not have failed to be carried to the water supply. Local conditions and methods of dealing with discharges at two of the invaded farms such as would ensure specific pollution of the watercourses proceeding from them direct to the reservoir	The only condition common to all the localities suffering fever was the water supply. Fever was prevalent in all portions of the borough conterminous with the water supply, and in those outside rural districts also using the same service, to the entire exclusion of all other localities, the few cases occurring elsewise admitting of easy explanation. Some of them residents elsewhere consuming the implicated water while at work. Indeed, there was special exemption from fever of those parts of the borough not supplied from the public works	At once on information of suspected danger to the water supply by reason of fever cases at the farms, the Lliw water was cut off, and cessation of fever was to be looked for—if caused by this water—about mid-July. As a matter of fact such cessation was witnessed It is estimated that at the date of cutting off the Lliw supply 100 cases of fever had already developed in the town during the preceding three weeks	BRIT. MED. JOUR., vol. ii, 1885, pp. 87, 111, 206.
162	1885, especially August	Fareham, Hants	Mr. J. Spear, L.G.B.	150 (?)	15	7,000	All	All	100	Pollution of water mains by numerous direct connections between water mains and sewers, and between service pipes and watercloset pans. Water service intermittent	Outbreak very severe, and especially fatal in the month of August. Above defects remedied at the end of 1885, and in the next succeeding three years enteric fever has been much less common in the town, and only 8 deaths have occurred therefrom in the whole population of Fareham	—	Official report to the L.G.B.
163	June to Sept., 1886	Swanage, Dorset	Mr. W. Harvey, L.G.B.	55	3	2,000	—	22	40	Disposition of the bowel discharges of 2 fever patients in such a fashion as to lead to infection of a stagnant stream a few yards from the dipping place of a dairy having no water supply on its premises	Of the next succeeding 12 households attacked, 9 were consumers of milk from the dairy in question, and 22 persons suffered from fever. One-sixth of the families drinking the milk were invaded during the whole epidemic, only 1 in each 150 families trading with other dairies being attacked	In mid-August the multiple cases of fever widely scattered over the town set up renewed epidemicity owing to prevailing methods of excrement disposal in relation to local water supplies and dwellings, leading to specific fouling of wells and air	Official report to the L.G.B.
164	Aug. and Sept., 1886	Fortune's Well, Isle of Portland	Dr. F. H Blaxall	80	8	291 (in invaded area)	All	All	100	Water supply from a spring, having in its near vicinity both imperfect sewers and filthy privy pits	Disease introduced from Egypt by a regiment of the line; 4 cases occurring *en voyage*, and 6 cases after landing at Portland. After occurrence of 4 of these last 6 cases, the disease appeared among the consumers of water from the Maiden Well Spring, and was limited to persons drinking this water; 36 families being invaded in as many houses out of 77 occupied dwellings in the epidemic area. Of 3 cases arising outside this area of 100 yards around the spring, 1 had just removed, 1 habitually drank the water, and 1 was in close attendance on a patient, probably therefore also using the water	No fever previously known for 15 years. The men from Egypt embarked at Alexandria on July 25th, and fever was limited to the regiment, no cases arising elsewise on shipboard. Hence, infection was doubtless derived in Egypt, which gave a period of incubation varying from 18 to 25 days in respect of cases developing after return to Portland	*Practitioner*, vol. xxxix, 1887, p. 157.
165	July to Oct., 1887	Mountain Ash, Glamorgan	Mr. J. Spear, L.G.B.	518	31	10,295	2,556	458	88	Public water main, which supplied the infected streets, found to be laid recklessly "immediately above, alongside, and even through old rubble drains"; carried through pipe drains wantonly smashed for its reception, the main itself leaking, and receiving into its interior liquid filth from soil and sewer. Intermissions of water service, of a nature to determine abundant leakage from the soil into the water main, had taken place shortly before the epidemic outburst	Disease in July suddenly assumed severe epidemic form, 163 cases occurring that month, 239 in August, and 97 in September. Of 391 houses supplied from the leaking main, and below its defective joint, 57 per cent were invaded. Within the whole "epidemic area" drawing water from this main, 52.8 per cent. of houses and 17.9 of population attacked and 88 per cent. of cases occurred: against 2.4, 0.6, and 12 respectively in adjacent localities. Many of the outside sufferers had evidently contracted the infection within the epidemic area	"Examination of earlier history of enteric fever in the district showed that since the water main in question was laid, in 1885, an epidemic prevalence of this disease has existed in the district supplied by it. Further, in 1886, there was, as in the following year, an outburst; of the houses then supplied from the main, below the point indicated above, 15.6 per cent. were invaded, whilst in neighbouring localities the corresponding proportion was only ½ per cent."	Report of Med. Officer. L.G.B., 1887.
1	2	3	4	5	6	7	8	9	10	11	12	13	14

1	2	3	4	5	6	7	8	9	10	11	12	13	14
No.	Date of Out-break.	Locality.	Re-porter.	Total Number of Cases	Deaths.	Population of Invaded Locality.	Number of Persons Supplied by Suspected Water.	Number of Cases amongst Drinkers of Suspected Water.	Percentage of Total Cases.	Exciting Cause of Outbreak.	Circumstances Implicating Water.	Observations.	Reference.
166	Sept. to Oct., 1887	Burnriggs, Carlisle R.S.D.	Dr. Hall. M.O.H.	38	2	130	? All	All	100	Well liable to pollution, and water found on analysis to be "an impure water being polluted by organic impurities." Percolation of filth from surroundings of defective pump regarded as having undoubtedly been the cause of pollution of the water	Outbreak of a sudden character, most of the 37 tenements in the village being invaded. An imported case presumably the origin of the outbreak, the spread being, according to Dr. Hall, the result of use of the polluted well water	Despite new pump-tree, cleaning of well, etc., the water remained for some time unusable	BRIT. MED. JOUR., vol. ii, 1887, p. 953; *Carlisle Journal*, Oct. 21st, 1887, Nov. 8th, 1887, April 10th, 1888.
167	Sept., 1887, to Dec., 1888	Cheltenham	Dr. E. J. Tatham	161 (in hospital)	?	—	—	Mainly	Large	Numerous surface wells, subject to pollution, and fed partly by surface drainage, furnished the drinking water to the poorest and most populous part of the town, that sunk in the sand-bed. Wells sunk in a porous soil traversed by sewers, old as well as new, and also having cesspools sunk in it	Epidemic originally broke out in those portions of the town served by these surface wells, after heavy autumnal rains following on a severe summer drought, impurities thus being washed into the pervious soil and thence to the shallow wells. Maximum intensity of disease from November, 1887, to April, 1888. There was throughout comparative localisation of the outbreak to these parts	Secondary causes helped to disseminate infection, such as milk supply, sewer gas, and the like	*Practitioner*, vol. xlv, 1890, p. 222.
168	Jan. to March, 1888	Buckingham	Dr. H. F Parsons L.G.B	114	5	3,000	300	30 at least	26	Pollution of a stream of water, used by 78 families, by means of a faulty drain which contained the infective excreta of a typhoid fever patient	In the first six weeks of the sudden epidemic outburst all the sufferers partook of the polluted water. Of households using the water 38 per cent. were invaded, against 3 per cent. of the rest of the population. Disease principally attacked children, the greatest water drinkers, in the epidemic area. Decline of the disease among the water consumers in March thought of as referable to the precaution of boiling the supply, exhaustion of specifically infected matter, and also to the fact that many of the susceptible persons had contracted the fever	Disease spread by entrance of sewer air, from sewers largely polluted, into dwellings; by the overcrowded condition and filthy surroundings of invaded houses, and other local circumstances	Official report to the L.G.B.
169	March, 1888	Keynsham, Somerset	Dr. Blaxall. L.G.B.	12	2	4,895	5 houses	All	100	Water supply from wells sunk close to the closet drains, the circumstances under which excrement was disposed of leading to percolation of filth to the water. Original case not traced	Spread of the disease undoubtedly due to the well waters, which were found on analysis to be polluted. Chloride of lime thrown down the closets and drains impregnated the drinking water. Drain bottoms found unjointed, with fall towards the houses	Disease no doubt also assisted by poisonous exhalations from closets and drains invading the dwellings	Official report to the L.G.B.
170	May to Nov., 1888	Pensnett and Bromley, Staffordshire	Dr. H. F Parsons, L.G.B.	56	13	Two roads involved	All	30 houses	88 per cent. of households	Locality derives its water supply from wells liable to surface pollution by sewage gutters, privies, etc. All analyses have resulted in condemnation of the wells. First case of fever treated at home, in the higher part of the infected area. Privy 26 yards from well	Next cases occurred in a block of houses adjoining that where the initial attack was treated, and lower down the hill. Well used was found to be polluted by sewage. Generally speaking, the disease spread down hill houses near the top being first invaded, thus favouring the theory of soakage into wells of the specific poison of typhoid. In a row of 8 cottages depending on one sewage-contaminated well, 6 were invaded. Incidence of disease chiefly on adult males exposed in their work to great heat, and consequently large water drinkers. Home-made beverages used by many, the water used being from these wells, and seldom all boiled	Other conditions favouring fever spread excluded as the cause of the outbreak. Of the 4 invaded houses outside the special area, the first person attacked in 3 had relations with patients in that area. In the remaining 1 serious sanitary defects existed	Official report to the L.G.B.
171	June to Dec., 1888	Hants County Lunatic Asylum, Fareham.	Mr. J. Spear, L.G.B.	115	6	900	All	All	100	Asylum has its own system of sewerage and water service. The former entirely remodelled in 1887. The latter from a well, with leaky drains close to it. Movement of underground water in the neighbourhood of the well from adjoining cemetery and asylum sewage farm. Ordinary pumping of the well influences the level of the underground water beyond these polluting media	Outbreak of 1888 the heaviest witnessed in the asylum, affecting both sexes of patients, officers, and servants. Ninety cases occurred in July and Augest, 22 in the three succeeding months	—	Official report to the L.G.B.
172	Aug., 1888	Loughborough, one street	Dr. Wm. G. Palmer, M O H.	Over 30	1	18,000	Only invaded houses	All	100	Serious contamination of a well by adjacent privies	Fever confined to houses in the street using water from this well	Well closed, no fresh case arising thereafter	BRIT. MED. JOUR., vol. ii. 1888, p. 437
173	Aug., 1888	Mangotsfield, Keynsham R.S.D., Glos.	Dr. Blaxall, L.G.B.	12	Nil	5,707	8 houses	All	100	Two imported cases of enteric fever in a row of cottages, the privies discharging into large cesspits not emptied for years and in dangerous proximity to the well. Well water doubtless specifically contaminated; found on analysis to be grossly polluted	Outbreak in 7 houses simultaneous, about five or six weeks after original cases came home. All used the one well. Residents in 2 houses in the row, and of others in the immediate vicinity, but using other wells, escaped. No community of condition among the invaded households save water supply	—	Official report to the L.G.B.
174	Jan., 1889 to June, 1893	Gainsborough R.S.D., Lincoln	Dr Bruce Low, L.G.B.	192	18	18,756	5,693	167	87	Pollution of the river Trent and its tributaries by the crude sewage of many towns, such as Derby, Bakewell, and Belper, with a combined population of 120,000 persons; also at times by the contents of Nottingham sewers. Newark and Gainsborough sewage discharges to the Trent; night soil from Huddersfield and Sheffield is spread in large quantities upon land draining to the Trent, and the river is further excrementally fouled by the dejecta of a large floating population. Much fever habitually in towns polluting the river, and hence the specific poison of typhoid has plenty of opportunity of finding its	In four years and a half ended June, 1893, there were 192 known cases of typhoid, of which 167 occurred in 10 villages using mainly water from the Trent or Chesterfield Canal. Only 25 cases in 41 villages, containing over 13,000 people, using well water. The respective attack-rates were 29 and 2 per 1,000 living. Even of the 25 cases, 2 at least are known to have drunk from the river, and 4 were imported. Further extension of fever prevented, it is thought locally, by habit of many persons to boil the river water. Villages habitually practising this precaution have practical immunity from fever	Data for periods antecedent to 1889 not obtainable	BRIT. MED. JOUR., vol. i, 1894, p. 530

	1889		M.O.H.				hold.			well, and foul alike to sight and smell, being found very impure on analysis. Dye stuff discharged into adjacent filth-polluted stream found also in well water	three medical men, among the farm staff and others in the house which the well served	reason, probably, of infection of milk stored in a room close to which passed a badly-jointed, inefficiently constructed drain, down which the evacuations of the initial case were doubtless thrown	JOUR., vol i, 1889 p 1250.
176	April to May, 1889	New Herrington, etc., Durham	Dr. D. Page, L.G.B.	275	26	16,400	4,400	273	99	Pollution of the Herrington reservoir by a feeder, hitherto unknown to exist, and which received the drainage of a farmhouse, the farm buildings, and of a cottage. Such pollution demonstrated by means of common salt poured down a crevice at the point of overflow of the drainage tank of the dwellings in question, with resulting heavy increase in the amount of chlorine in the reservoir. Method by which the pollution became specifically infective not demonstrated	All but 17 cases occurred within the area of supply, and of these exceptions, 15 unquestionably drank of the water away from home. Over 100 attacks occurred within a space of nine days, in houses circumstanced alike only as to water service. Adjacent large populations, and even some within the epidemic area, taking other water, wholly escaped. Households were attacked earliest near the reservoir, the time of invasion being later as the distance therefrom increased	When pollution of the Herrington reservoir was proved, the unique plan of boiling all the water prior to its entry to the reservoir was resorted to as a temporary measure, and pending fresh permanent arrangements	Report of Med Officer L.G.B., 1889.
177	July to Nov., 1889	North Ferriby, Sculcoates R.S.D. Yorkshire	Dr. Barry, L.G.B.	16	3	473	—	16	100	Well liable to pollution, as shown by analysis	The cases occurred in eight contiguous households and all the sufferers drank of the one well. The fever ceased a fortnight after closure of the well	—	BRIT. MED. JOUR., vol. ii, 1889, p. 960.
178	Aug. to Oct., 1889	Sutton, Sculcoates, R.S.D., Yorkshire	Dr. Barry, L.G.B.	30	1	1,280	56	24	80	Pollution of well by means of a leaky cesspit, into which the excreta from a case of enteric fever had been cast in early August. Analysis confirmed the suspected pollution, and persons were warned to boil the water	Fourteen persons, all drinkers of the water, simultaneously attacked in late August. Outbreak almost wholly confined to persons taking water from the polluted well, all resident in two terraces. All who habitually boiled the water entirely escaped infection. Of 7 persons attacked elsewhere, 6 were in one house, one of whom—the first case—frequently drank from the pump spout; whilst the remaining sufferer had frequent relations with the fever-stricken terraces	—	BRIT. MED. JOUR., vol. ii, 1889, p. 960
179	Aug. to Sept., 1889	Hessle, Sculcoates, R.S.D., Yorkshire	Dr. Barry, L.G.B.	25	2	2,557	—	25	100	Water supply of infected area from two bore wells, the water of both of which was noticed to be much discoloured after rain, and one at least of which was open to pollution by an adjacent leaky cesspit. Isolated cases of fever in both localities of annual autumnal occurrence	All the cases among drinkers from these two wells, 7 in 4 houses in the one, and 18 in 6 houses in the other locality	—	BRIT. MED. JOUR., vol. ii, 1889, p. 960.
180	Jan., 1890, to June, 1893	Newark	Dr. Bruce Low, L.G.B.	297	37	14,457	About 8,000	About 230	78	Pollution of the river Trent and its tributaries by the crude sewage of large towns by the drainage of heavily excrementally-manured land, the populations leading to befoulment of the river having among them much habitual fever, with consequent numerous opportunities for specific contamination of the Trent. Public water service of Newark from wells and culverts on the banks of the Trent, and subject to admixture by the river water by percolation and pumping when necessary	Of 53 cases of fever in 1890, 73 per cent used the public water supply; in 1891, of 125 persons attacked, 91 per cent.; in 1892, of 69 cases, 68 per cent.; and in 1893 to June, of 50 cases, 82 per cent. used the public supply. Of the whole number of attacks in the 3½ years, 78.5 per cent occurred among that half of the population drinking from the public service. All other conditions likely to foster the spread of fever eliminated as having concern with this large prevalence	Period in question selected as compulsory notification only began on January 1st, 1890	BRIT. MED. JOUR., vol. i, 1894, p. 530.
181	June, 1890	Farnecombe, Surrey.	Dr. E. L. Jacob, M.O.H.	15	—	—	Mill hands	13	87	Well usually resorted to being repaired. In these circumstances water from the river Wey was resorted to by mill hands. Enteric fever known to have occurred at Godalming, up stream, in April and May, the excreta and foul water of that town being discharged into the river	River water first used on June 2nd; outbreak began on or about June 16th at the mill a mile below Godalming. Information as to 2 cases not forthcoming; fever elsewise limited to the mill hands	The sewage of Godalming was allowed to enter the Wey without previous treatment	BRIT. MED. JOUR., vol. ii, 1890, p. 94.
182	Sept. to Oct., 1890, Dec., 1890, to Feb., 1891	Tees Valley	Dr. Barry, L.G.B.	1,463	160	503,616	219,435	1,334	91	Flooding of the river Tees precedent to two distinct prevalences of fever; the river before the first being "much flooded," and before the second having "an 8-foot flood," due to melting snow. The river had numerous opportunities for specific contamination from known occurrences of fever, and the accumulated polluting material on its foreshore needed but the presence of flood water to bring it down stream	River Tees had "stinking abominations" along its banks; it acted as a "common sewer." Some 20 villages and hamlets and the town of Barnard Castle drained to the river, and washings of highly manured lands, drainage of graveyards, of farmhouses, of privies, urinals, waterclosets, "loads of stinking refuse," and midden refuse found their way into the Tees. Water of river distributed, after sand filtration, through works of Darlington Corporation and Stockton and Middlesbrough Water Board. Attacks among river-water consuming population 31 and 26 respectively per 10,000 in the two epidemics, against 3 and 1 among remaining population. In special area of 17 districts rates in ten river-drinking communities 29 and 24 against 3.5 and 1.5 in other seven areas. Combining the two epidemic periods 15 persons drinking Tees water were attacked for each unit of the remaining population.	Various sanitary defects obtained in the districts comprised in the scope of inquiry, but only one in common in the epidemic area, namely, water supply	BRIT. MED. JOUR., vol. i, 1891, p. 412; vol. ii, 1892, p. 1098; vol. ii, 1893, p. 1021, etc.
183	Oct., 1890, to Jan., 1891	Smyth's Row, Dawley, Hayes, Middlesex	Dr. Roberts, M.O.H., and Mr. Evan Evans, L.G.B.	11	2	132	132	11	100	The excreta from an unisolated typhoid case were buried in the garden about 10 feet from a well, the water of which was polluted	About a month after burial of the specific evacuations the other cases arose, there having been in the interval heavy rain showers. The disease affected only the drinkers of the polluted well water.	—	Local report and official report to the L.G.B.
184	Nov., 1890	Arundel, Sussex	—	43	3	2,644	—	40	93	Water supply temporarily from a public pump in the market square, during some repairs rendered necessary in connection with the machinery at the waterworks	Forty of the 43 attacks in 26 houses were among drinkers of the market square pump	Much diarrhœa in the town in August and September. Well closed	BRIT. MED. JOUR., vol. ii, 1890, p. 1204
1	2	3	4	5	6	7	8	9	10	11	12	13	14

1	2	3	4	5	6	7	8	9	10	11	12	13	14
No.	Date of Outbreak.	Locality.	Reporter.	Total Number of Cases.	Deaths.	Population of Invaded Locality.	Number of Persons Supplied by Suspected Water.	Number of Cases amongst Drinkers of Suspected Water.	Percentage of Total Cases.	Exciting Cause of Outbreak.	Circumstances Implicating Water.	Observations.	Reference.
185	Nov., 1890, to March, 1891	Bedworth, Warwickshire	Dr. Parsons, L.G.B.	11	7	—	14 houses	9	81	Contamination of a well in Sprigg's yard inevitable owing to its situation, but source whence specific pollution was derived not traced	The well was situate in a narrow yard containing 14 houses, the yard surface being badly paved, and having an open brick gutter in the centre, discharging into a drain frequently stopped and depositing sediment on the yard surface. Two privies existed connected with large, deep ash-pits. Pump 12 feet from a large, deep, open midden privy. Fever once set going, carried to other houses by personal intercourse in visiting and nursing the sick	Enteric fever in Bedworth has tended to occur in outbursts in particular localities, due in Dr. Parsons's opinion to the entrance of specific infectious matter into local wells situate amid a prevalence of filth, defective sewers, and badly kept midden privies	Official report to the L.G.B.
186	1890	Brill, Buckinghamshire	Dr. Willoughby	24	3	1,880	12 families	All	100	Two surface wells, 4 feet deep, so situate as to receive storm waters and surface washings. Organic pollution evident on analysis. Fæcal fouling of ground in proximity of both wells. Water directly or indirectly infected by the evacuations of the initial case	Outbreak limited to users of these wells, the pollution of each being followed by a batch of cases. Boiling of water stayed the fever for a time, but it broke out again within three weeks of neglect of this precaution	The only case among consumers of "deep" well water was a young man who had opportunity, by visits, of using the wells. He sickened twenty days after partaking of "refreshments" at an infected house	BRIT. MED. JOUR., vol. i. 1891, p. 179
187	Jan., 1891, to Jan., 1892	Coalville, Leicestershire	Dr. Parsons, L.G.B.	115	23	6,000	All	All	100	Grave insanitary conditions of drainage, excrement disposal, and water supply prevalent, the wells, only of moderate depth, being open to pollution by adjacent drains, privies, and excrementally-manured gardens, the wells being, moreover, usually dependent for supply on rain water falling on a soil thus saturated with filth, some of it specifically poisonous	The fever was confined to Coalville, and the inquiry resulted in tracing localised and sudden outbursts in close relation with particular wells contaminated with the specific fever poison	The conditions of drainage and excrement disposal had their share in fostering spread of the fever, defects in these respects being abundant in the invaded localities	Official report to the L.G.B.
188	Aug. and Sept., 1891	Providence Villas, Wood End, Hayes, Middlesex	Dr. Roberts, M.O.H., and Mr. Evan Evans, L.G.B.	8	—	42	42	8	100	A drain became blocked, and the overflow, consisting in part of privy contents specifically infected by the evacuations of a previous case of typhoid, soaked into the well furnishing water to the locality	Only consumers of the polluted water were attacked	—	Local report and official report to the L.G.B.
189	Sept., 1891, to June, 1892	King's Lynn, Norfolk	Dr. R. Bruce Low, L.G.B.	135	15	18,265	All	135	100	Specific pollution of the river Gaywood, whence King's Lynn derives its water supply, was brought about by a rapid thaw in mid-February. In a house situate on the river bank eight cases of fever occurred from November, 1891, to mid-February, 1892, the excreta being first frequently emptied on the garden sloping to the stream, and at a later stage of illness to a trench 35 yards from the brink. Heavy rain took place in early February, followed by frost, again by heavy snow, and later in the month by a thaw, the accumulated snow being drawn to the river owing to hardness of the ground, and carrying with it the typhoid dejecta which had been accumulating in the garden, the frozen path forming a ready channel for conveyance of the excrement to the river. Within a week of this occurrence an outburst of diarrhœa took place in King's Lynn, amounting to hundreds of cases, and a week later there followed multiple attacks of enteric fever among diarrhœa patients and in other persons	The water supply was the only community of condition common to the affected area. Water derived from springs 6 miles from King's Lynn, and flowing as the Gaywood river to the borough, with numerous opportunities for pollution by human excrement and the like. The slop water of Grimstone village and other hamlets drains to the river, also the drainage of a churchyard, the overflow of cesspools, urinals, slaughter-houses, and manured gardens finds its way to the stream, the water of which is inadequately filtered prior to distribution	Another possible exciting cause of the outbreak was the disposal on gardens adjoining the river of filth from the town excrement depôt, probably containing by the beginning of 1892 the specific bowel discharges of fever patients, the thaw of February transferring the material to the river	Report of Med. Officer, L.G.B., 1892-93.
190	Oct. to Dec., 1891	Rotherham, Rawmarsh, and Greasbrough	Dr. Theodore Thomson, L.G.B.	251	35	57,160	60 per cent.	218	87	—	The water supply of the epidemic area (the only community of condition) is derived from two gathering grounds, each formed by the convergence of two valleys, neither being free from means of dangerous pollution. On one of these two sections, the "high level," the special incidence of the fever rested, to the extent, indeed, of 87 per cent. of the total cases. In Greasbrough the fever was wholly among consumers of the water of the particular section. This high level service is derived from a gathering ground comprising cultivated land highly manured with farmyard and also privy midden refuse. Moreover, sewage from whole villages finds its way into the water, the section being supplemented by two springs, one situate in the centre of Rotherham, a town of 40,000 people, and one in which the privy midden system prevails. Analyses of extra and intra-urban water alike of a compromising nature, during a series of years, the town well water being especially impure; "pollution by urine, cesspool drainage, or similar impurity," being the opinion of one analyst in respect of the well. None of the three filter beds had been cleaned since 1885, one not since 1881, with resulting accumulation of filth found on inspection	Epidemic prevalence not related to insanitary conditions of sewerage, drainage, or excrement disposal, nor to a contaminated milk supply, but to this particular section of a public water service in the hands of the Rotherham Corporation, a section that had in previous years been similarly detrimental to the health and lives of consumers of its water	BRIT. MED. JOUR., vol. ii, 1892, p. 663; Report of Medical Officer, L.G.B., 1892 to 1893
191	Oct., 1891, to Feb., 1892	Temple Cloud, Somerset	Dr. Sweeting, L.G.B.	11	2	465	—	4	36	The initial cases of fever occurred in one of four cottages deriving their water supply from a spring emanating from abandoned iron workings, and piped to a culvert near a ditch, both ditch and culvert being under water in time of flooding of river Cam. A flood took place just precedent to the occurrence of the fever in the invaded family. An attack, suspected to be of fever, was housed in another of the four cottages in August, the privy discharging its contents into the ditch in	The water spout of the spring referred to is, during flood, covered by a stream or ditch, which receives much excremental matter, and also by the waters of the Cam, which is polluted by cottage slops, ashes, and vegetable refuse. Assuming, as is held, that the attack in August was really one of enteric fever, all the conditions were present needed for specific contamination of the stone conduit at the mouth of the spring by means of the excreta from the infected privy during the October flood	The disease once set going in the initial household, spread by means of careless nursing in three additional cottages in another part of Temple Cloud having insanitary conditions of excrement disposal and water supply. No community of milk supply. Compulsory notification not in force. Early cases not heard of by health officer for some time, with resulting absence of	BRIT. MED. JOUR., vol. i, 1892, p. 634; vol. ii, 1892, p. 1369.

		Lymington Hants	M.O.H.							ng matter thrown down finding its way into the well			ii, 1892, p. 91.
193	April to July, 1892	Northallerton.	Dr. Lumley, M.O.H.	35	3	3,800	Some 30 houses	—	Nearly all	Well sunk in gravel with strong clay watertight bottom. Drain ran close to the well used by the first patient, and leaked into the well. Evacuations thrown into the common ashpit and adjacent sink. All wells in the locality open to the same water movement, and sunk in soil "charged to overflowing with impurities of every kind"	All the cases occurred in a very limited locality wholly supplied by shallow wells, all of them open to sewage contamination, and by wells, moreover, which were no doubt specifically polluted by the evacuations of the first 2 patients. All the early cases were in persons who had drunk of the well impregnated by the excreta of the first 2 patients	Disease doubtless in some measure kept going by reason of poisoning of air by sewage gases with which the soil was saturated	BRIT. MED. JOUR., vol. ii, 1892, p. 340.
194	Sept., 1892, to April, 1893	Bishop Auckland, co. Durham	Dr. Eustace Hill, County M.O.H.	70	?	10,527	All	All	100	Water supply from the river Wear, which is much polluted by sewage above the intake, directly or indirectly from all the towns and villages in the upper portion of the Wear Valley. Gross sewage pollution takes place quite close above the intake, and at a time coincident with the outbreak the river was receiving specifically contaminated sewage near at hand	The cases occurred in 61 houses, 30 being invaded in January, when fever is not generally prevalent, and all in houses in which the only common factor was water supply. Other known causes could be set aside. At South Church, an adjacent village, 4 cases occurred during the epidemic prevalence, and 4 only, these all being in houses receiving the Bishop Auckland water, all the other houses in this and all those in the surrounding villages, taking different water, escaping	The sanitary authority none the less desired to expend £12,000 on increased supply from the same source, the polluted Wear	BRIT. MED. JOUR., vol. ii, 1893, p. 658
195	Oct., 1892, to March, 1893	Chester-le Street, Durham	Dr. Maclean Wilson, L.G.B.	58	4	4,864	60 per cent.	—	95	During October, and again in January and February, the bowel discharges of enteric fever patients were, owing to defective drainage arrangements at fever-infected cottages up-stream, passing into a stream which in turn supplied the water mains of one of two companies. The method of filtration of the water in question not such as to prevent the passage of germs of fever into the distributing pipes	No inter-relations of sufferers; no community of milk service; the only sanitary circumstance common to the invaded houses being water supply. All but two were served by the water of one of two companies, and infection of these two dwellings was accountable in other fashion. Consumers of the other company's water, numbering 445 families, wholly escaped the fever. The conditions existing in relation to supply of the implicated service were such as to favour dissemination of specific contamination, being faulty alike as to intake, filter bed, filtering material, and distribution	Invaded houses were widely scattered over the district, and sanitary defects were not infrequently associated with the disease; but houses not affected were equally sharers in these defects, the most glaring of which were found in regard of houses which possibly derived their infection by some way other than that through which the general outbreak arose; the condition, indeed, of many invaded dwellings being fair. Few of them had connection with the town sewers.	BRIT. MED. JOUR., vol. ii. 1893, p. 289.
196	Nov., 1892, to Jan., 1893	Ryedale, Yorkshire	Dr. R. Bruce Low, L.G.B.	53	2	17,600	600	36	68	An October flood of the river Rye, permitting of the accumulated polluting material along its banks being washed down stream, the water from the river furnishing the domestic supply to the four villages of Nunnington, Ness, Butterwick, and Brawby, in the rural districts of Kirkbymoorside and Malton	In the 600 persons located in these four riverside villages, 31 fever attacks occurred from November, 1892, to January, 1893; and in the twelve months 36 cases out of 53 attacks taking place among the total populations in the two rural districts amounting to nearly 18,000 persons. Incidence on the four villages, therefore, 60 times greater than on the rest of the districts. Water supply was the only feature common to the epidemic area. The river receives the sewage of Helmsley, and the drainage from manured fields strewn with human excrement from local privies, and with night soil from Leeds; and ample opportunity offered for the reception by the river of the specific fever poison; all this taking place above the villages in question.	At Nunnington all fever ceased within a fortnight of warning that the water should be boiled. In other villages like action was followed by similar cessation of the disease.	BRIT. MED. JOUR., vol. ii. 1893, p. 418
197	Jan., 1893	Woodham Walter, near Maldon, Essex	Dr. Thresh, M.O.H.	4	nil	About 20	About 20	4	100	Cottages at a lower level than a farmhouse, derived their drinking water from a stream which was subject to pollution by the washings from a defective privy near the spring which fed the stream. Especially was this so in time of heavy rain. Some weeks prior to the outbreak the farmer had been ill with a complaint of a febrile nature, accompanied by diarrhœa	Disease limited to 4 residents in the cottages supplied with the polluted supply, the disease being confined to these persons	Dr. Thresh regards the outbreak as plainly due to the intermittently contaminated water	Annual Report to the Maldon rural sanitary authority, 1893.
198 (a)	May to Nov., 1893	Worthing, Broadwater, and West Tarring	Dr. Theodore Thomson L.G.B.	1,411	126	19,290	(*a*) 15,600 (about) (*b*) 2,800 (about)	1,398	99	Water supply obtained from 3 wells, A, B, and C, with 3 headings, 2 headings serving as connecting tunnels between the three wells. The heading driven from well C only in the early part of the year, and a large fissure struck, the inrush of water being so great that the men in the tunnel had to fly for their lives. Soil overlying the chalk in which were sunk these wells and headings, liable to sustained pollution by sewage	The commencement of the fever outbreak was coincident in point of time with the commencing use of the water from the new heading. The excreta of almost all the typhoid cases occurring in April and May would pass along the leaky main sewer that lies to the west of the waterworks. Moreover, up to June the excreta of typhoid patients were also passing along a defective sewer to the east of the waterworks. Of the 1,257 cases occurring in Worthing, no fewer than 1,255 are known to have drunk of the water. In Broadwater, of 41 cases, 34 had been in the habit of drinking the water. In West Tarring, 15 of the 17 earlier cases, and in West Worthing, 4 of the 6 earlier cases, were found to have occurred in consumers of the water. An experiment by Dr. Thomson demonstrated the opportunities which the water had of becoming polluted. A ton of salt in solution was thrown into the old shaft sunk in 1885, but closed on account of a large quantity of doubtful water then met with. Shortly after the commencement of the experiment, over an hour, the amount of chlorine in the water of well C had risen from 5.0 to 35.8 parts per 100,000	The water was supplied in an unfiltered condition to the town	Official report to the L.G.B.
98 (b)	July to Nov., 1893	West Worthing and West Tarring	Dr. Theodore Thomson L.G.B.	90	?	3,186	2,900 (about)	All	100	Water supply from a couple of wells furnished with boreholes and sunk in the chalk below the town. Conformation of the ground such that there is a ridge which runs through the district dividing West Worthing and West Tarring, the water mains following the contour of the ground	The invaded area in each of the towns was the lowest part. If any infective material gained access to the higher mains it would naturally gravitate to the two invaded areas. The mains are fitted with ball-hydrants and filth from the hydrant box or the roadway might easily pass into the mains when a ball had fallen as the result of reduced pressure in the mains. How the infective material got into the mains, however, there is no sufficient evidence to show	The water was not filtered prior to distribution to the inhabitants	Official report to the L.G.B.
	2	3	4	5	6	7	8	9	10	11	12	13	14

1	2	3	4	5	6	7	8	9	10	11	12	13	14
No.	Date of Outbreak.	Locality.	Reporter.	Total Number of Cases.	Deaths.	Population of Invaded Locality.	Number of Persons Supplied by Suspected Water.	Number of Cases amongst Drinkers of Suspected Water.	Percentage of Total Cases.	Exciting Cause of Outbreak.	Circumstances Implicating Water.	Observations	Reference.
199	June to Oct., 1893	Atherstone	Dr. S. W. Wheaton L.G.B.	112	18	4,991	—	—	83 during epidemic period	Supplementary water supply from the surface drainage of a piece of common land, thickly covered with animal ordure, and mud and filth from a large pond; whilst the collecting tank has in its immediate vicinity a place much used for purposes of defæcation by numerous tramps	This water turned into practically empty mains each night during drought from May 20th to July 15th, when complaints of turbidity compelled its stoppage. Water also delivered prior to, during, and since that time at public tap. Levels of district such that this supplemental supply could reach only one section of the mains. In this section, from mid-June to August 6th, during which period influence of nightly supply may be held to have been operative, 93 per cent. of cases occurred; in the next four weeks 83 per cent. so occurred, and 57 per cent. in the next five weeks. There was a special incidence of disease among adult males; and moreover the people living in the epidemic area being almost entirely of the working class. and having to get up early in the morning, would draw off their water earlier, and would therefore be more likely to draw off the water supplied overnight than those in other parts of the town. As a matter of fact, the people living in the epidemic area used this water to a considerable extent, owing to the fact that when their supply from the town water was cut off at stated intervals, they had near at hand the public tap, at which a supply was always to be obtained.	When once firmly established, the disease was probably kept going by means of the prevailing midden privy system, although polluted water practically stagnant in depression of one of the mains may be thought of as having concern after the implicated service ceased to be turned into the mains, and the public tap was always available	BRIT. MED. JOUR., vol. i, 1894, p. 264.
200	July, 1893	Sennen Cove and a farm, Penzance R.S.D.	Dr. J. Mudge, M.O.H.	?	11	—	?	All	100	Typhoid fever treated at a farm, the house lying higher than the well, which latter doubtless became polluted by percolation	All the persons ascertained to have suffered typhoid either drank the implicated water or milk contaminated by water from the suspected well. The closing of the well stopped the spread of the disease	Information concerning the outbreak did not reach the health officer very early, owing to non-adoption of the Notification Act of 1889. A few years back a well in close proximity to that here in question was condemned	Special report of M.O.H.
201	Aug. and Sept., 1893	Easington, co. Durham	Dr. Eustace Hill, County M.O.H.	"Somewhat serious outbreak"	4	—	?	All	100	A well on the village green so situate and constructed as to be especially liable to surface and subsoil pollution. Analysis showed the water to be grossly contaminated with organic matter	All the cases occurred in consumers of the water of this well	The whole water supply of the village from shallow wells known, almost without exception, to be polluted, the drainage of the large and overcrowded churchyard being thought of as passing through the village by way of the subsoil water	Quarterly Report. 1892 (iv) of County Health Officer.
202	Aug. to Nov., 1893	Cyfarthfa Brickyard, Merthyr Tydfil	Dr. C. E. G. Simons, Deputy M.O.H.	11	3	?	?	6	55 (really 100; see Col. 12)	Brickyard water supply by percolation from two feeders, from rivers Taff Fawr and Taff Fechan. Just above intake of first feeder was a deposit of filth on the river bank, and some drainage from Cefn village also reaches the river at this point. As regards second feeder, there was evidence of specific pollution of river above the intake by typhoid excreta during July	First 7 cases in 4 different residential localities, but all among drinkers of the implicated supplies, and 6 of them in the brickyard. The remaining 4 cases all related to previous ones. One of the patients (case No. 7) partook of the water after its use had been forbidden	—	Annual Report, Merthyr Tydfil M. O. H., 1893.
203	Sept., 1893	Greasbrough, Yorkshire	Dr. J. F. Cheesewright, M.O.H.	41	4	3,292	2,630	? All	? 100	Water supply chiefly from shallow wells, all communicating, there being reason to suspect specific contamination of the highest surface well by the excreta of typhoid fever	The disease was sudden in its onset, whole streets being attacked, and the local conditions as to water supply being those named in Col. 11	The unventilated condition of the sewers is locally regarded as having possible relation to the outbreak	BRIT. MED. JOUR., vol. ii, 1893, p. 812
204	Sept. to Dec., 1893	Laurieston, co. Stirling	Dr. J. C. McVail, County M.O.H.	41	3	—	?	39	95	Village built on an open gravelly soil, doubtless the source of the water used for drinking, which is liable to pollution. Wells furnish the supply, analysis showing unfavourable character of the water	A single case in March and two attacks in September occurred in persons using the same well. The disease increased rapidly in November, and, with the exception of one or two secondary cases, practically all the attacks were grouped round two wells. Careful inquiry led to elimination of all other known causes of typhoid. Discontinuance of the implicated wells, or boiling of their contents—much delayed owing to obstinacy of residents—was followed by cessation of the epidemic	Local prejudice in favour of old wells was with difficulty overcome, even in the face of this experience of the use of polluted well water	Annual report for co. Stirling, 1893
205	Autumn, 1893	Paisley and Johnstone, Renfrewshire	Dr. Campbell Munro, County M.O.H.	672	?	76,093 (1891)	85,850 (estimated and including other places)	—	—	Pollution of water supply of Paisley Water Commission. See col. 13. [The dry hot summer of 1887, which was followed by enteric fever prevalence in Paisley, attributed to the washing down of impurities into the reservoirs by the succeeding rains.]	Rate of attacks on population drinking the Paisley water, 7.8 per 1,000; on persons otherwise supplied, 0.5 per 1,000. In "landward" districts consuming Paisley water, attack-rate 15.1 per 1,000. In the borough of Renfrew, where no fever cases had been known for three months, no attacks occurred save in the little suburb of Moorpark, which alone derives water from Paisley	Mr. Macalpine, of Paisley, states that in samples of water drawn from Rowbank Reservoir on October 23rd the typhoid bacillus was found. All the conditions necessary for the propagation of the bacillus were present in a bog at the south-east end of the reservoir	BRIT. MED. JOUR., vol. ii, 1893, pp 1032, 1187